

THE SAFETY ASPECTS OF JIG AND FIXTURE DESIGN
IN THE FURNITURE MANUFACTURING INDUSTRY

A THESIS

Presented to
the Faculty of the Division of Graduate Studies
Georgia Institute of Technology

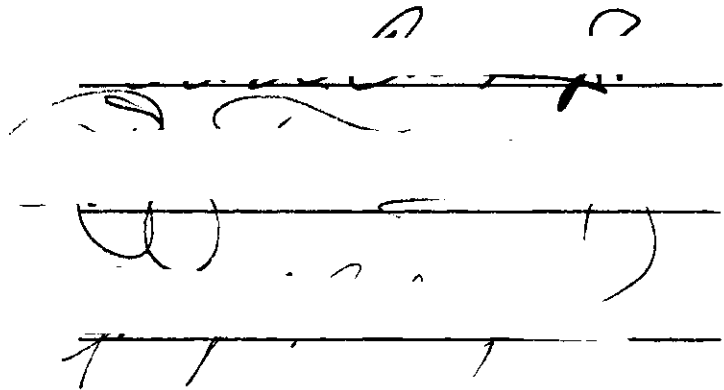
In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Safety Engineering

By
William Loyd Jenkins

June 1951

THE SAFETY ASPECTS OF JIG AND FIXTURE DESIGN
IN THE FURNITURE MANUFACTURING INDUSTRY

Approved:

Three horizontal lines with handwritten signatures or initials above and below them. The top line has a signature above it and a checkmark below it. The middle line has a signature above it and a checkmark below it. The bottom line has a signature above it and a checkmark below it.

Date Approved by Chairman May 25, 1951

ACKNOWLEDGMENTS

Appreciation is gratefully expressed to Professor William N. Cox, Jr. for his many useful comments and constructive criticisms in the capacity of faculty advisor during the prosecution of this project.

To my wife, Jeanette, I owe an especial debt of gratitude for her continued patience, and for her allowing so many home responsibilities to be neglected while the data was being obtained and compiled.

TABLE OF CONTENTS

	PAGE
Acknowledgments.....	iii
Summary.....	1
Definitions.....	2
Introduction.....	3
The Problem.....	6
Safety Considerations.....	9
The Table Circular Saw.....	11
The Band Saw.....	32
The Jointer.....	42
The Shaper.....	50
The Router.....	78
The Drilling Machine.....	82
The Belt Sander.....	87
Storage of Jigs and Fixtures.....	94
Conclusions.....	96
BIBLIOGRAPHY.....	99

THE SAFETY ASPECTS OF JIG AND FIXTURE DESIGN
IN THE FURNITURE MANUFACTURING INDUSTRY

SUMMARY

Representative jigs and fixtures presently used in the furniture manufacturing industry were examined to determine the relationship between certain design characteristics and the accident hazards inherent to the use of such equipment.

Selected plant installations were analyzed from information obtained by research and observation, and the correlation of safe design features with those of increased production were shown. Machining conditions utilizing jigs and fixtures were compared with those in which no accessories of this type are used, and the increased safety benefits afforded the operator by the use of these items were shown.

The group of machines on which these jigs and fixtures were most suitably adapted included the table circular saw, band saw, jointer, shaper, router, drilling machine, and belt sander. With one exception, no consideration was taken of those machines whose operations depend solely upon mechanical feeding methods, nor was the closely related subject of machine guarding approached.

The necessity for proper storage facilities was discussed, and the primary reasons why efficient storage methods are conducive to the habitual use of jigs and fixtures were noted.

DEFINITIONS

In some instances, terms are used which are common only to the woodworking industry. For this reason, definitions are included in this section of the presentation for reference purposes.

Accident Frequency Rate: The number of disabling injuries per million man-hours of exposure.

Accident Severity Rate: The total time charged for occupational injuries per thousand man-hours of exposure. The time charges for each injury include actual calendar days of disability for temporary total disability, and penalty charges for deaths and permanent injuries.

Jig: An appliance which guides a cutting tool with relation to the work. Either the work is held in the appliance or the appliance is affixed to a large work piece. The work and the jig are usually held together with clamps that are quickly tightened or loosened, and generally the jig is easily moved by the worker.

Fixture: A device for holding the work during the machining operations. The name is derived from the fact that a fixture is always fastened to a machine or bench. It may also be thought of as a special purpose vise.

Saw Kerf: The space left in a work piece resulting from a saw cut. It is equal in width to the maximum thickness of the saw blade and may be any length.

Multiple Cutting After Pattern: The procedure of cutting a number of like pieces such as table tops, chair seats, or other similarly shaped parts. The pieces are cut several at a time to match a given pattern.

Point of Operation: That location on a machine at which the cutting blade contacts the stock and cutting, shaping, or forming of the piece actually occurs.

INTRODUCTION

The accident rates of the furniture manufacturing industry have been consistently high in the past. For example, during the period 1946-1948 inclusive, the accident frequency rate (number of disabling occupational injuries per million man-hours exposure) of the furniture manufacturing industry was 16.08. For the same period, the accident severity rate¹ (total time charged for occupational injuries per thousand man-hours exposure) was 1.15. These rates are of only one of forty major industries for which accident statistics are compiled annually by the National Safety Council.² Inasmuch as the average frequency and severity rates of all industries combined are 11.93 and 1.13 respectively, the rates of the furniture industry are only slightly higher. It is pointed out, however, that most of the accidents reflected in the rates of the furniture manufacturing industry occur in the limited segment of the operations using power-driven machinery. The accident experience of many other less hazardous phases of the industry such as assembly, upholstery, finishing, etc., appears to maintain the furniture industry rates at a level lower than is characteristic of the machine operations of the industry.

An inevitable result of the occupational injury is an added cost item which is likely to be appreciable. The cost of the accident must be divided into its more important elements if its extent is to be

¹See Definitions, page 2.

²"Three Year Industrial Frequency and Severity Rates -- 1946 - 1948," Accident Facts (Chicago: National Safety Council, 1949), p. 37.

freely realized. The cost of medical treatment and payments for disability benefits under the respective Workmen's Compensation Acts are usually recognized. However, a larger additional group of cost elements are also consistently present and usually involve costs substantially greater than those of medical treatment and disability payments. These less obvious cost elements³ might include:

1. Wages paid for time lost by workers who were not injured.
2. Damage to material or equipment.
3. Wages paid for time lost by injured worker other than workman's compensation payments.
4. Extra cost due to overtime work necessitated by the accident.
5. Reduced output of injured worker after return to work.
6. Cost of learning period of replacement worker.
7. Cost of time spent by higher supervision and clerical workers on investigations or processing compensation, and other reports.

My observations indicated that after consideration of such costs brought about by accidents, some companies within the furniture manufacturing industry have directed specific attention toward methods and means of reducing their accident rates in order to reduce unit production costs.

Since the more severe accident exposure lies in the machine-operation phases of production, the increased use of jigs and fixtures⁴

³R. H. Simonds, "Determining Accident Costs," National Safety News, 62: 22-23, August, 1950.

⁴See Definitions, page 2.

as a part of such operations is receiving consideration as a safety measure and a production-efficiency measure. It was felt that a detailed study on this subject would contribute useful information which might serve as a basis for wider and more intelligent use of jigs and fixtures. An extensive library search was made to accumulate available written information on the safety considerations of jigs and fixtures. Then a study was made of representative jig and fixture practices presently used or contemplated within certain plants of the furniture manufacturing industry. Each of a series of common furniture-manufacturing machines was considered in turn. For each machine, jigs and fixtures for typical furniture-manufacturing operations were studied and the inherent hazard exposures were contrasted with those present where jigs and fixtures were not utilized. Design characteristics of specific jigs which appeared to reduce operational safety were cited and remedies suggested.

THE PROBLEM

The efficient and safe operation of woodworking machines in the manufacture of furniture requires a controlled relationship between the machine, the material being processed, and the persons involved in the machine operation. Present machine processing methods within the industry rely largely on forces exerted by the hands of the operator to hold or to move the material and/or the machine in accordance with the relationships prescribed by the method. In many such operations the degree of control essential to the satisfactory accomplishment of that particular section of the process requires the use of the hands in close proximity to the point of operation frequently accompanied by the exertion of considerable force. Although each type of machine is different in its detailed characteristics, and operations may vary widely on the same or identical machines, one factor is inherent. The soft, fibrous nature of wood as compared with other industrial materials necessitates the use of sharp cutting edges moving at high rates of speed. Consequently, the hazardous exposure created by the use of the hands in close proximity to the point of operation is intensified.

The lack of a controlled relationship between the material-machine-person factors with consequent probability of accidental injuries, material damage, machine damage, and other production delays may be illustrated with the following situations:

A. Inadequate Control of Material.

1. Material "grabbed" and thrown suddenly by machine due to improper tool setting, improper feeding, or material defects as knots or checks.

2. Material falling or moving because of unstable position on machine.
3. Size or shape of material inappropriate for the machine.

B. Inadequate Control of Machine.

1. Tools or other machine parts dislodged from machine as when cutters are thrown from shaper head.
2. Point of operation out of position due to failure of counterweights.

C. Inadequate Control of Person.

1. Insecure position of person including falls and other loss of balance.
2. Vision interference or faulty vision.
3. Excessive personal strength requirements, fatigue, distractions, etc.

The adequate control of all factors without overtaxing or endangering the person (usually the hands) is basically a matter of transferring some of the control exerted by the hands to other agencies such as automatic or semi-automatic feed equipment jigs and fixtures, etc. The universally excepted use of the guide for ripping operations with a table saw and in fact, the table itself are efforts to relieve the task of the hands in positioning and moving the material in the ripping operation. The use of properly designed jigs and fixtures would accordingly seem to offer considerable promise in the maintenance of the material-machine-person relationship essential to efficient, safe production.

Within the furniture manufacturing industry, observations show that there still exists a tendency toward the belief that widespread use of jigs and fixtures within the plant will be so expensive to install

and difficult to maintain that their use is precluded. However, the rapid growth of such usages within the industry even in cases of small-lot production is providing proof of their practicality. Several inexpensive, quickly constructed jigs and fixtures suitable for small-lot operations are illustrated in succeeding portions of this study.

The objectives of the study are:

1. To show how jigs and fixtures may be used to advantage in the reduction of the frequency and severity of accidents in both large and small scale operations.
2. To illustrate the inter-relationship of safety and production.
3. To analyze certain jig and fixture practices in the industry so as to determine the relationship between the design of such equipment and the accident hazards presented by such practices.
4. To analyze a series of representative plant installations together with appropriate literature to determine the design principles applicable.
5. To correlate such design principles with the specific varieties of hazards presented to obtain a measure of the degree of hazard control.
6. To suggest areas of the problem in which further study is required.

SAFETY CONSIDERATIONS

The most logical time to consider safety in the development of a jig or fixture is during the design period. It is at this time that the features of safe operation can be incorporated to assure that there will be a minimum of protective machine guarding required. The following are some of the principles adhered to that are consistent with accepted production practices:⁵

1. The appliance should be safe to handle loaded or empty, i.e., be devoid of all projections and sharp corners that could catch the operator's clothing, hang on the machine or work bench, or cause hand injuries.
2. Controls and adjustments if any, should be located convenient to the operator to preclude the necessity of reaching over or around the appliance, particularly when the jig or fixture is used on a power cutting machine.
3. Jigs and fixtures should be strong enough for the job, i.e., support the part and the pressure of the work without allowing spring in the jig or the work piece.
4. The designs should incorporate standard clamping devices such as star hand wheels, wing nuts, cam clamps, and lever clamps to avoid the necessity for handling wrenches, thus eliminating many mishaps that usually accompany the use or misuse of this hand tool.
5. The line of the clamping pressure should fall on or between stops to prevent spring in the work. The clamping strain should fall within the fixture.
6. Pressure of the cut should fall against the solid part of the fixture rather than against some clamp or flange.

⁵F. H. Colvin and L. L. Haas, Jigs and Fixtures (New York: McGraw-Hill Book Co., Inc., 1948), p. 5.

7. Locating points should be visible and easily accessible to the operator for cleaning purposes when reloading.
8. Jigs should be of proper size to be readily handled.
9. On jigs that must be lifted frequently during the process, adequate handles should be provided.
10. Care should be taken to design the jig so that the hands are clear of the cutting blades during loading, cutting, and reloading cycles.

THE TABLE CIRCULAR SAW

One of the most widely used woodworking machines is the table circular saw. Its versatility in the number of operations which may be performed lends itself well to varied discussion in this project. Due to its very nature, it is an extremely hazardous machine and its operation presents many problems which usually must be solved in advance by careful planning.

When the blade is in motion, the hazard of revolving teeth is naturally present. In addition to guards ordinarily used on the saw, there are certain methods of further protecting the operator by controlling his contact with the saw through the use of various jigs and fixtures.

Insignificant as it may appear, the push stick (Figure 1) can be made a very useful appliance when ripping stock to narrow widths. If the stock is started through the saw with the left hand while the push stick is used by the right hand, the hazard to the operator is reduced during the cut. Proper use is essential however. If the push stick is made correctly, the stock will be held to the table and at the same time, moved in its horizontal plane from the reaction of the component forces exerted by the operator. As a result of this action and the lateral guiding reaction exerted by the ripping fence, the material being cut is controlled in the three planes. It is noted also that care is taken to provide sufficient length in the stick to allow the hand to clear the top of the fence.

For the operation of ripping stock thickness-wise or for cutting grooves in the edges of wide stock, a device known as a "feather

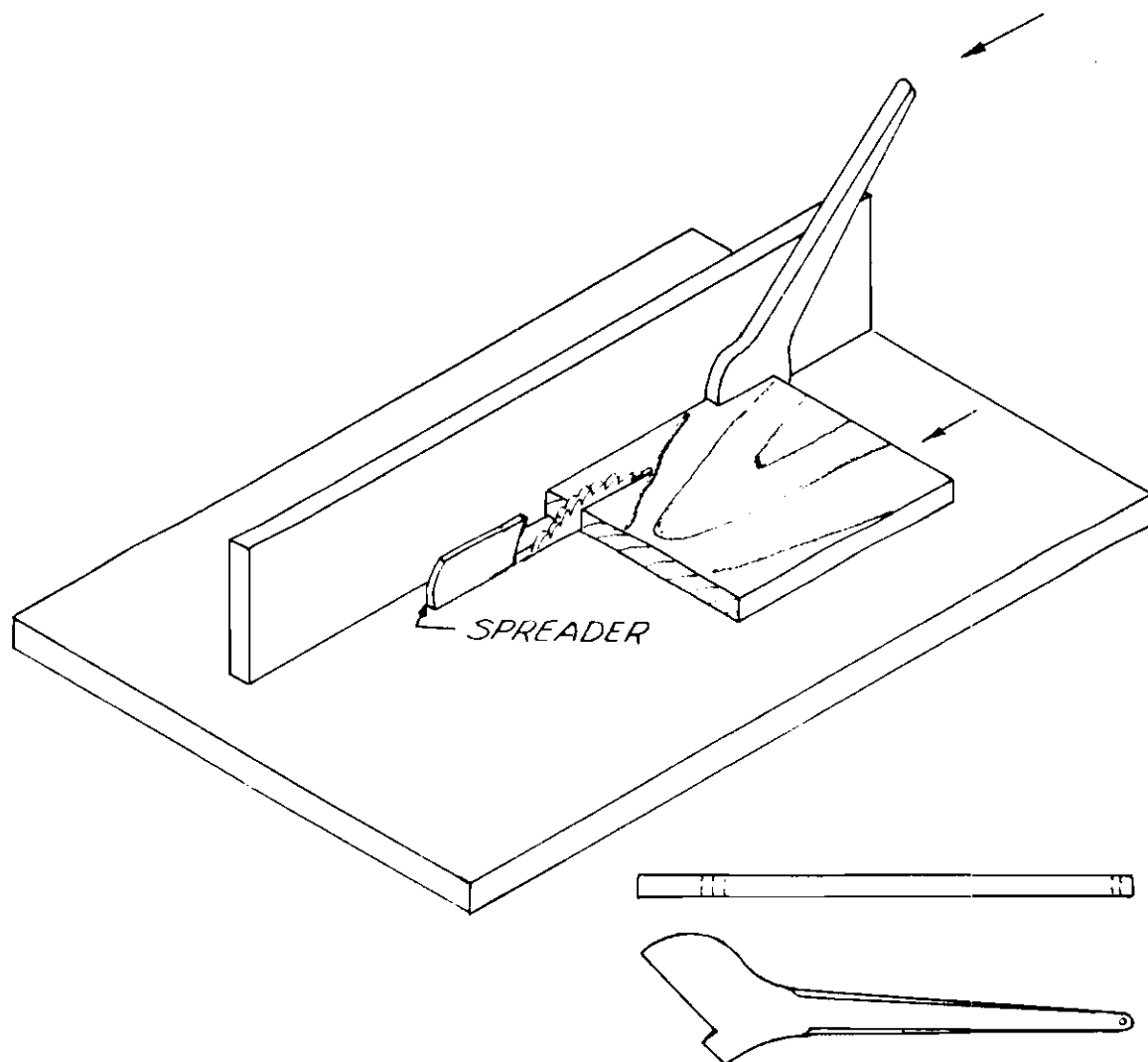


Fig. 1

Courtesy of Williams Furniture Co.

board" or a "comb" is of great help in handling the material safely and efficiently. It is usually made from a 1 inch hardwood board with straight grain, and from 3 to 8 inches wide according to the size of the machine. Its length also varies with the width of the saw table. One end is squared and the other cut at an angle of about 60°. The latter end is given a series of parallel saw cuts about 1/4 inch apart (Figure 2).

The feather board is clamped to the saw table in a manner such that the sawed end is parallel to the ripping fence and located with its far edge projecting slightly beyond the front of the blade, bearing against the side of the stock being cut. In this way, the work piece is firmly guided through its relatively unstable cutting path without danger of being forced out of line. The hands of the operator force the stock to the table with little exposure since the saw blade does not protrude through the material in this operation. Also, the reaction force of the saw is considerably less due to the cut being made with the grain. The feather board is not placed opposite the saw as in that position the stock would be forced against the saw, causing the blade to over-heat and wobble.

To saw bevels and chamfers, three methods may be used. Tilting the ripping fence is the most common practice, and tipping the saw table is the less convenient procedure. On some machines the ripping fence cannot be tilted whereas others have tilting arbors, which is the third method.

When the first method can be used, the fence should be tilted to the desired angle and firmly locked in that position. The side of

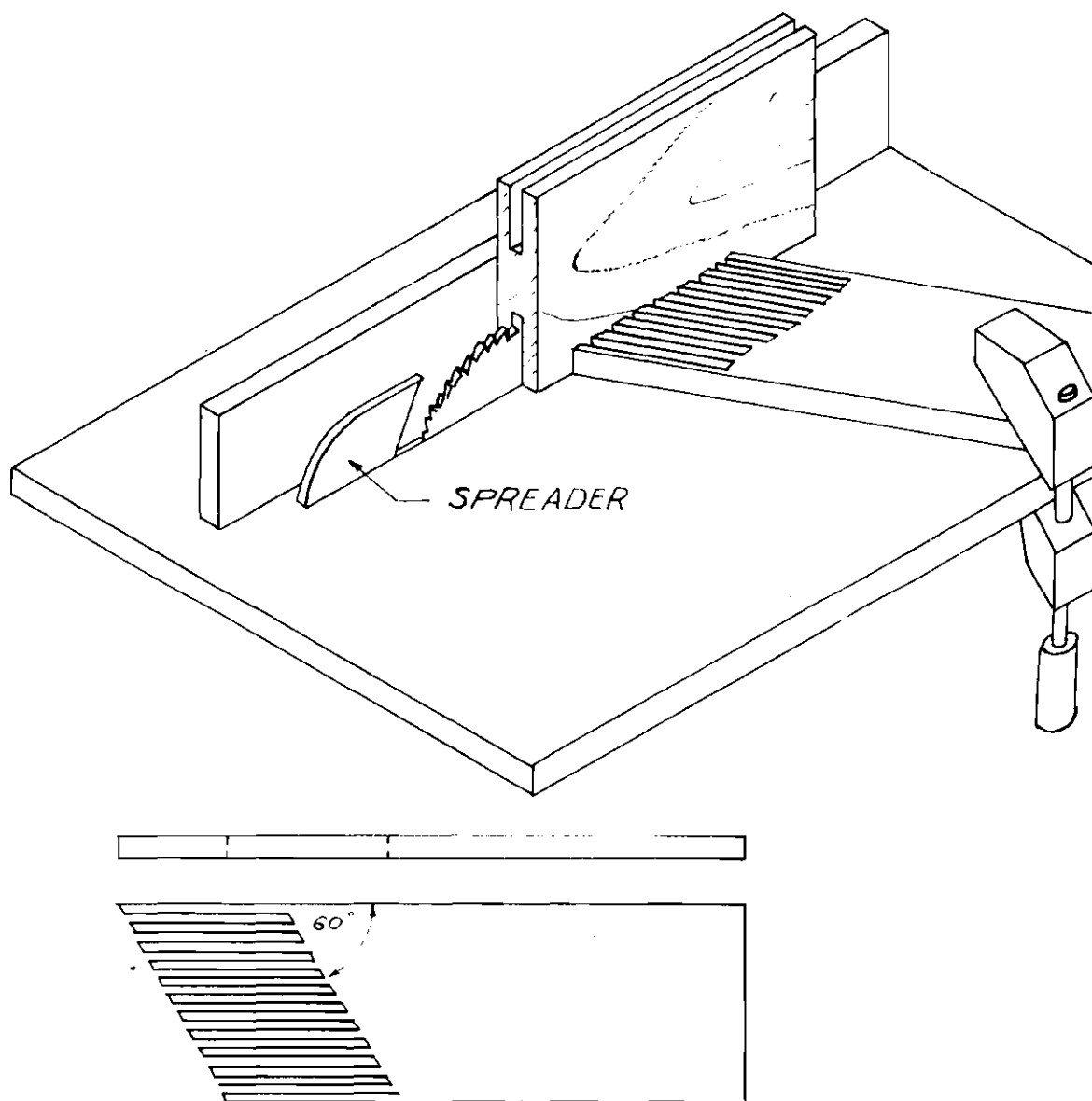


Fig. 2

Courtesy Williams Furniture Co.

the stock is held against the inclined fence by auxiliary hold-down boards clamped to the table as illustrated in Figure 3. These hold-downs could very well be feather boards similar to that discussed in the preceding paragraphs.

In using the second method, the table is tilted and locked in place. Most tables tilt to the operator's left. If possible, the ripping fence should be fastened to the left of the saw, providing a support on which the stock can rest as the cut is made (Figure 4). This is an important safety measure, since the fence, if allowed to remain in its usual position to the right of the blade, would allow the stock to follow its natural tendency to slide against the turning blade, causing a kick-back on the operator.

The third method is utilized when large or heavy material is to be mitered or edge-beveled. It is sometimes inconvenient to handle the job efficiently and safely on the tilting table saw and impossible with the inclined fence type because the stock would come in contact with the floor before it could be placed in position for machining. It is under such circumstances that the tilting arbor saw is advantageous for cutting the stock at the proper angle (Figure 5). Although no use of jigs and fixtures is involved in a case such as this, it is pointed out that the proper selection of machine to do a certain operation is always important.

Tapering is another function of the table circular saw. Legs for tables, chairs, and stools can be done readily and safely with the use of a very simple jig that is shown in Figure 6-A. It consists of a small board with a notched block attached with screws at any point

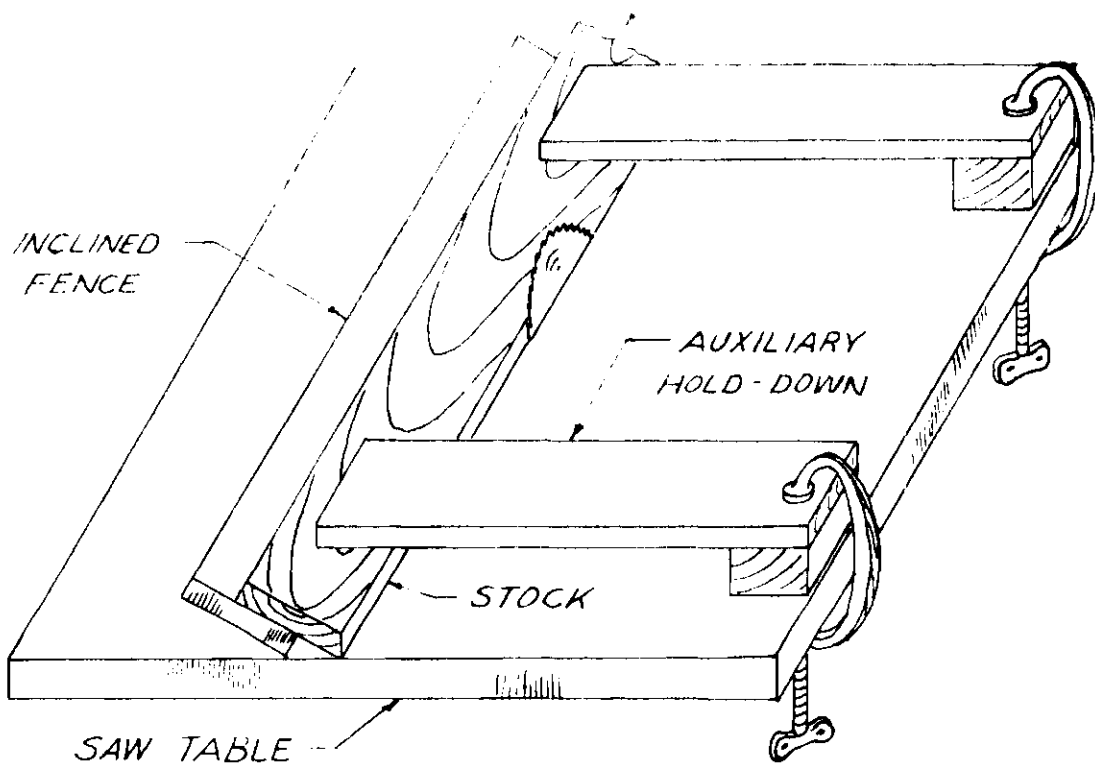


Fig. 3

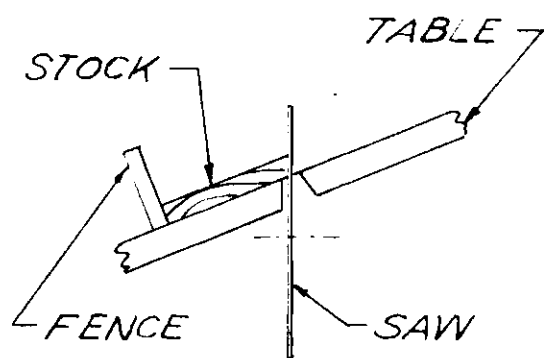


Fig. 4

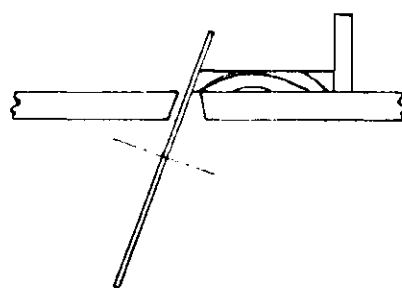


Fig. 5

Courtesy of H. Hjorth, *Machine Woodworking* (New York: Bruce, 1947), p. 48.

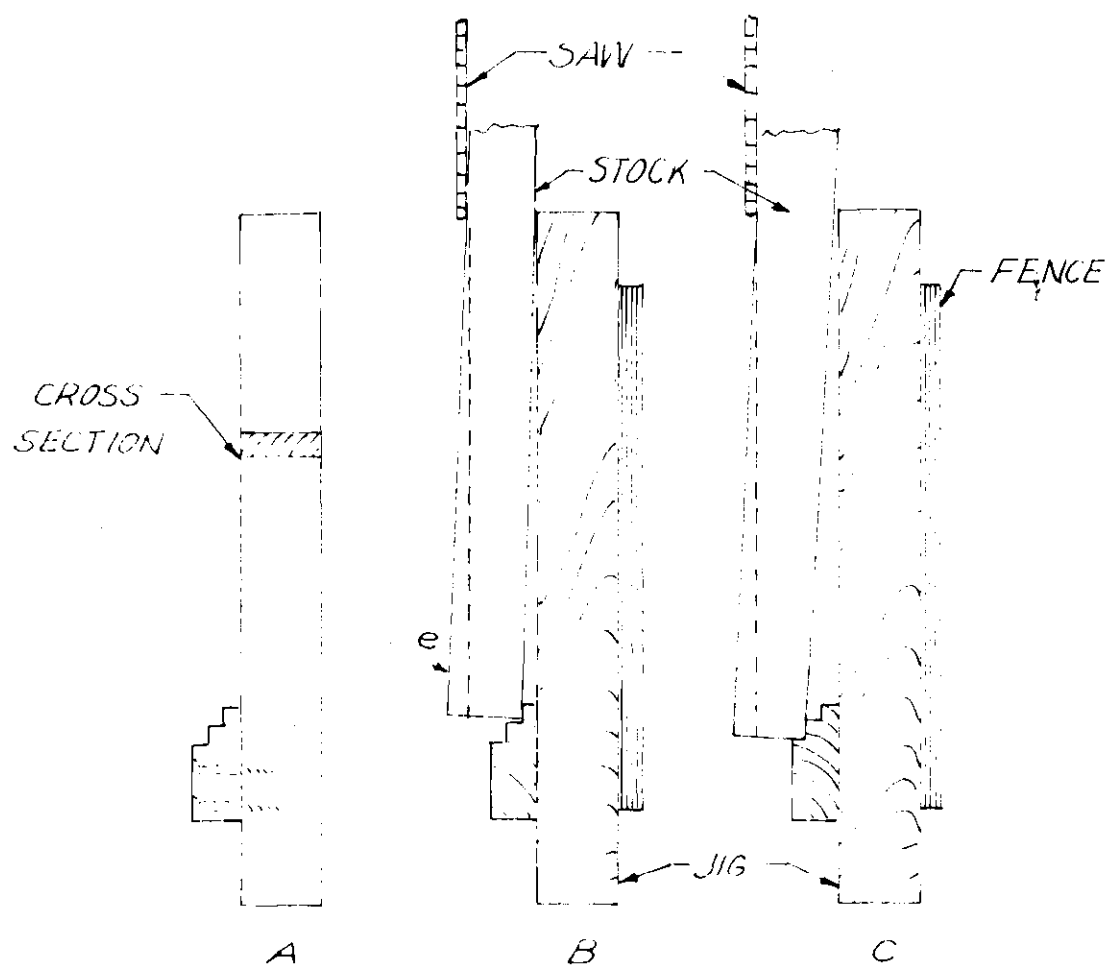


Fig. 6

Courtesy of Williams Furniture Co.

according to the length of the taper desired. Since the jig moves against the ripping fence, the notches must be equal to the amount of taper to be cut. This jig is advantageous in that it relieves the operator of trial and error procedure as to taper, and at the same time eliminates the necessity of his holding the stock at an angle as it passes through the saw. As shown in Figure 6-B, the first cut "e" is made with the stock in the first notch. It is then rotated and placed in the second notch to complete the taper (Figure 6-C). Essentially, this jig is a combined push stick and positioning device that serves to control the machine-material relationship in the horizontal plane. The machine-operator relationship is improved in that the operator's hands are not required to approach the blade at an unsafe distance.

A shallow rabbet often is cut on the edge of a round table top for the purpose of molding the edge. This can be done by using a "cradle" fixture in which to rotate the table top (Figure 7). Since the depth of the rabbet cut is usually equal to the width of the kerf,⁶ the distance between the fence and the outside of the saw is equal to the thickness of the stock.

In Figure 7 it is seen that the stock is bound on the back side by the saw fence, supported from the bottom by the saw blade itself. With all of the resulting components of the work piece accounted for, it is necessary for the operator to produce only the downward force sufficient to make the cut, and enough revolving action to complete the

⁶See Definitions, page 2.

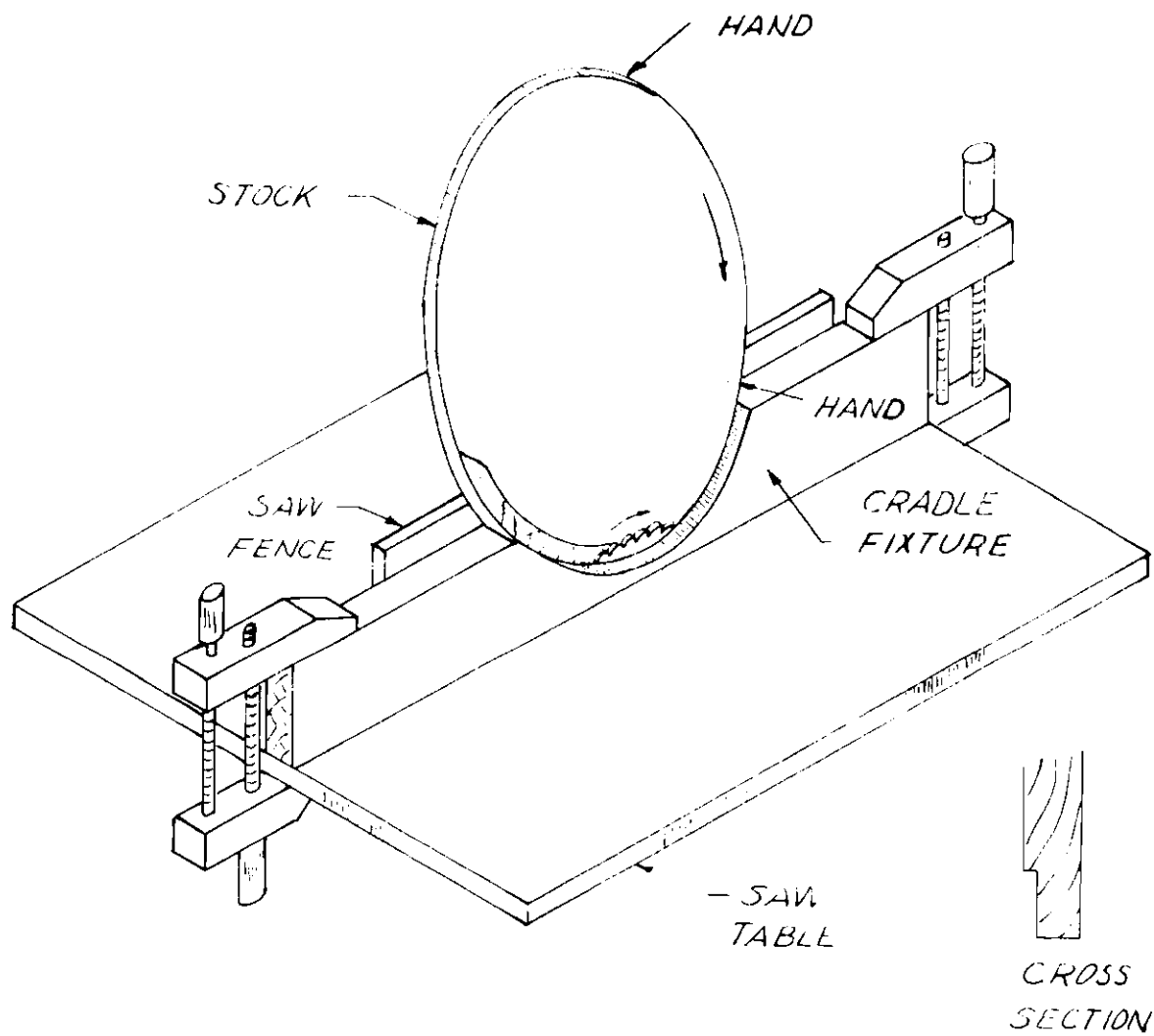


Fig. 7

Courtesy of Williams Furniture Co.

cycle. With this arrangement, there is no need at any time for the operator to approach the blade nearer than the primary (upper most) surface of the fixture. However, this method has its limitations. In the event that a shaper is available, it should be used for the operation because of the advantage offered by the stock resting in a horizontal plane rather than being held vertically by the operator.

Another operation performed on the table circular saw is mitering. This operation presents a stock-holding problem in that any kind of miter cut is made on an angle with the natural grain of the wood. As the usual ripping fence cannot be used, there arises a need for some means of holding the stock to prevent its being thrown from the operator's hands while the cut is being made.

Shown in Figure 8 is a conventional miter fence attachment made by the manufacturer of the saw as an accessory. It has an adjustable miter guage for varying the angle of cut in addition to a hold-down clamping bar. Since the entire assembly is guided on the saw table by a tongue and groove arrangement, all of the components of exerted forces are received by the attachment and the operator needs only to actuate the assembly for the cut.

For making miter cuts of shorter and narrower stock a shop-made jig similar to that shown in Figure 9 is more suitable. The first cut is made as the operator holds the stock to the right of the saw, followed by the opposite end being cut while the piece is nailed to a mitered stop block on the left side of the jig. In this manner, the stock is mitered and cut to length at the same time. Even very short pieces are cut easily and safely due to the holding action exerted by the jig

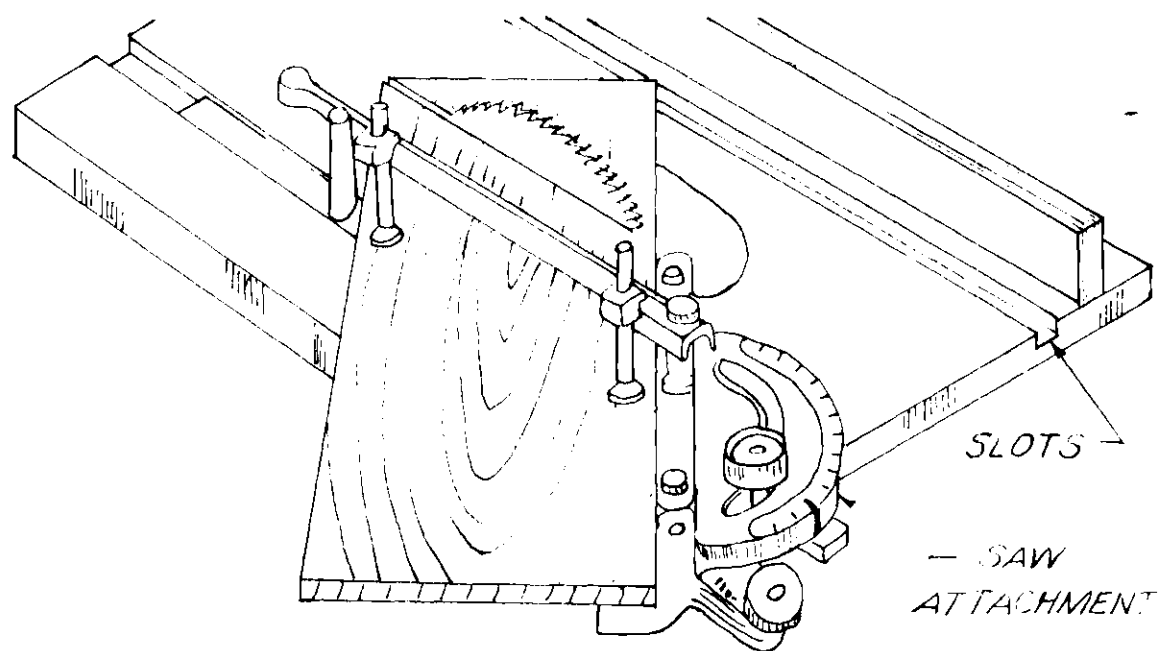


Fig. 8

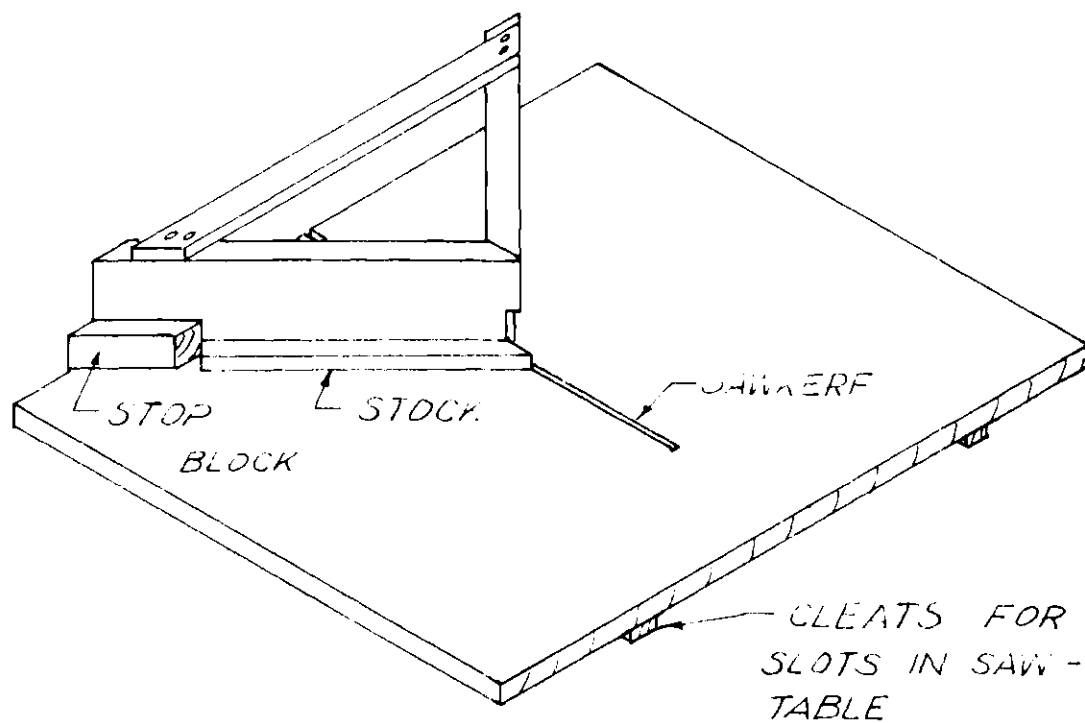


Fig. 9

Courtesy of Williams Furniture Co.

and to the fact that the operator is not required to guide the stock other than to exert a horizontal force sufficient to complete the cycle. Inasmuch as the stock can be nailed down or held in place with one hand, no considerable exposure is presented by the actuating movement. However, this jig can only be used on saw tables having two slots to receive the guiding cleats.

Tenon cutting can be done safely and simply on the circular saw by using a dado head as the cutter. This is the method that most resembles the operation of the tenoning machine. However, to do this work successfully, it is necessary to cut the stock to accurate length and thickness. Sawing the check-cuts while holding the stock with the hands only is a very dangerous procedure, which should not be attempted. Some of the smaller types of circular saws are equipped with a special tenoning attachment as shown in Figure 10. This appliance holds the work rigidly in position and requires the operator to exert only a horizontal force in order to guide it along its grooves in the table. Dangerous exposures are further reduced by the handle provided to assure a safe distance between the hand and the saw blade.

When this accessory is not available, a shop-made jig can be constructed readily and easily to fit the particular operation in question (Figure 11). The work piece, having been placed against the vertical support, is held firmly in place by the clamp while the entire assembly is moved horizontally against the ripping fence until the cut is completed. Although this arrangement does hold the work securely, there still exists the possibility that the operator's hands will contact the blade. Furthermore, its use is limited to small scale

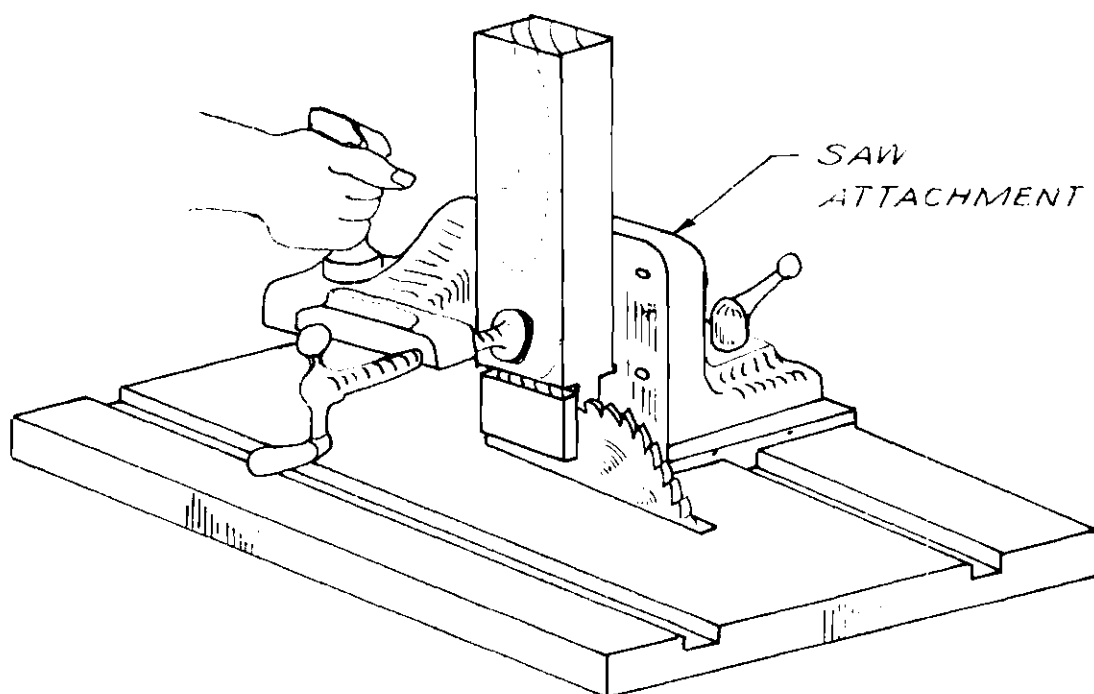


Fig. 10

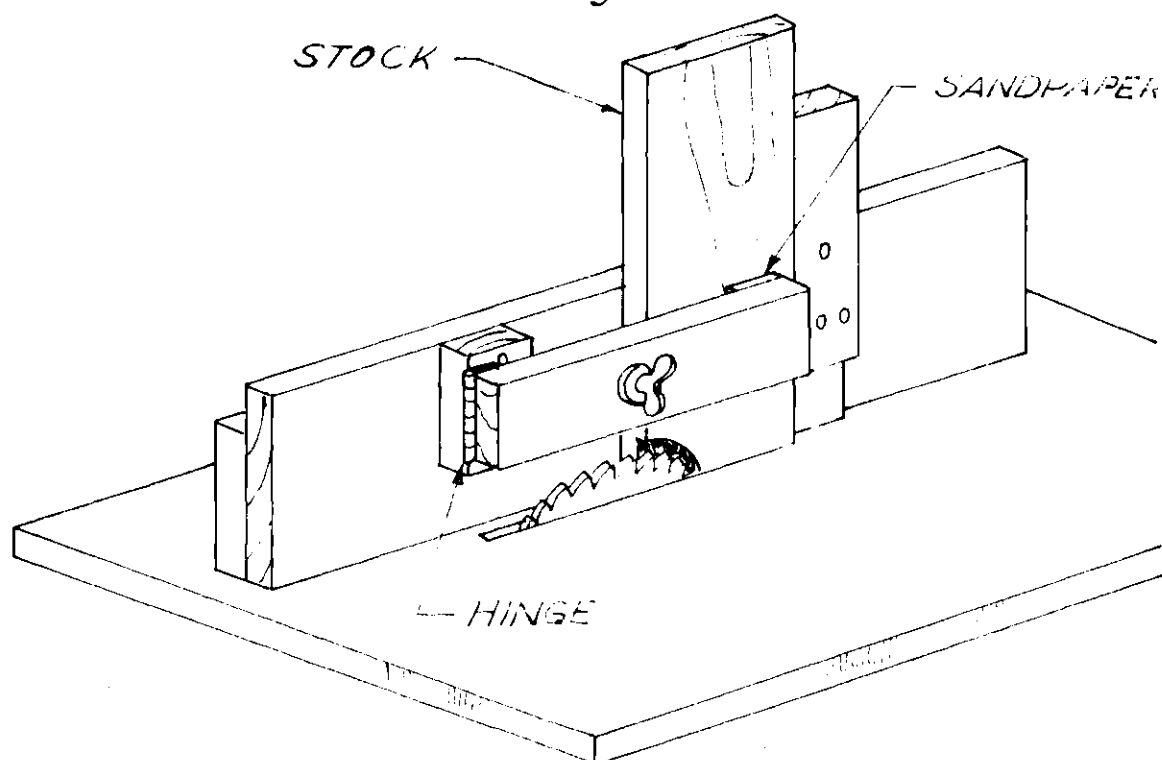


Fig. 11

Courtesy of Williams Furniture Co.

operations. If the cut is enlarged appreciably, there exists the chance of the entire assembly being thrown from the operator's grasp.

"Multiple cutting after pattern"⁷ can be accomplished quickly, safely, and accurately on the table circular saw by using the simple fixture shown in Figure 12. Since it consists only of a one inch board notched on each end to accomodate screw clamps, there is no problem of rigidity here. However, the stock is held in position by spurs protruding through the pattern. As the stock is moved into position to receive its series of straight cuts, it is acted upon by the combined downward and lateral forces from the operator in order to be guided past the saw. The projecting edge of the clamped fixture exerts its reaction to these combined forces to guide the pattern through its straight path for the cut.

Although the relatively shallow cutting operation presents no serious hazard from the blade itself, there exists the tendency for the work pieces to be twisted radially from the operator, which in turn would jeopardize his safety. The accumulation of waste under the jig creates another hazard due to the possibility of kick-back toward the operator.

For cove moldings and hollow or concave parts of other moldings, the oblique sawing method is useful. As the ripping fence cannot be adjusted in the oblique plane on some machines, two guide boards clamped diagonally across the saw table and parallel to each other can serve this purpose (Figure 13). This method is not widely used in mass

⁷See Definitions, page 2.

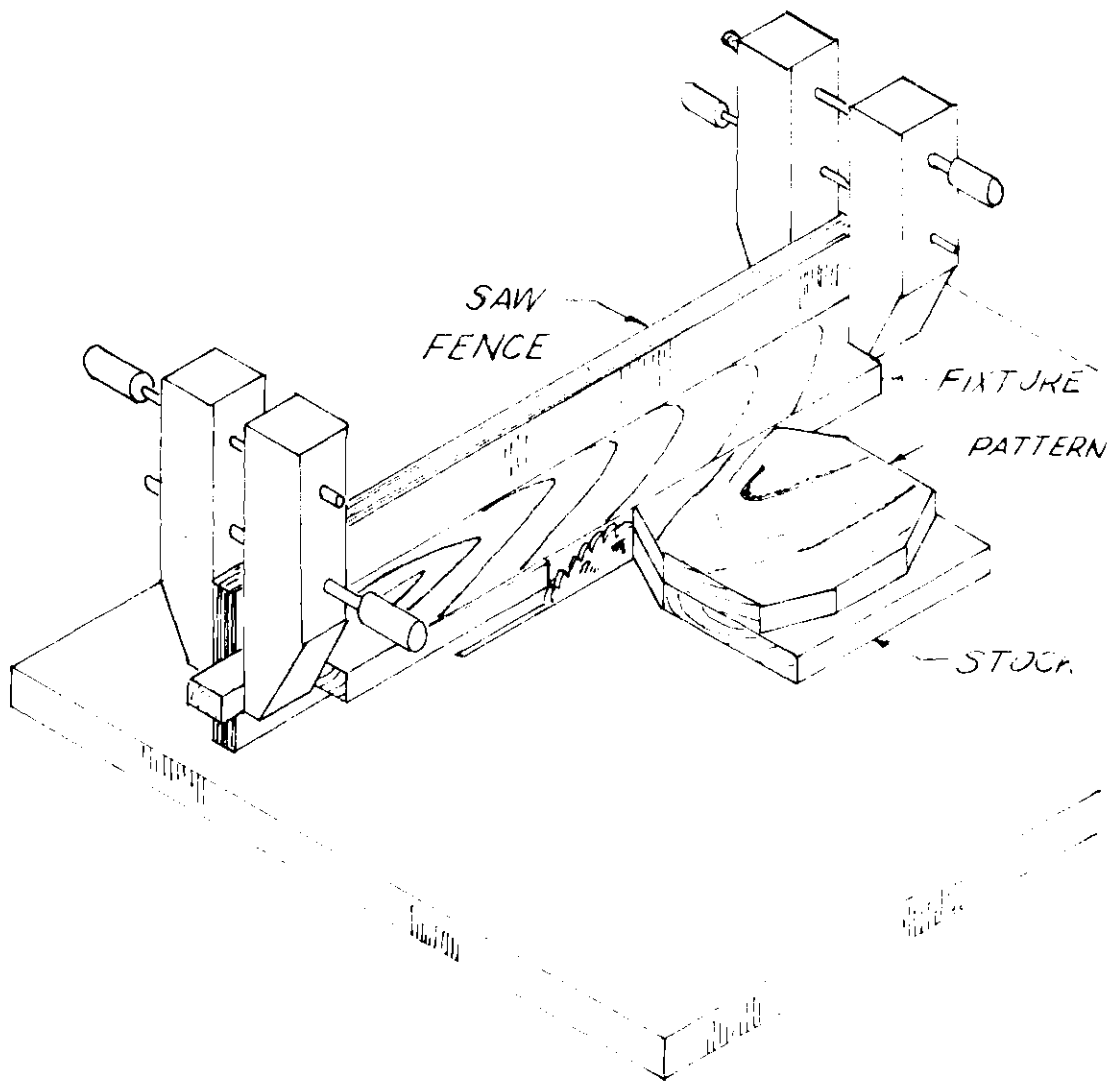


Fig. 12

Courtesy of Williams Furniture Co.

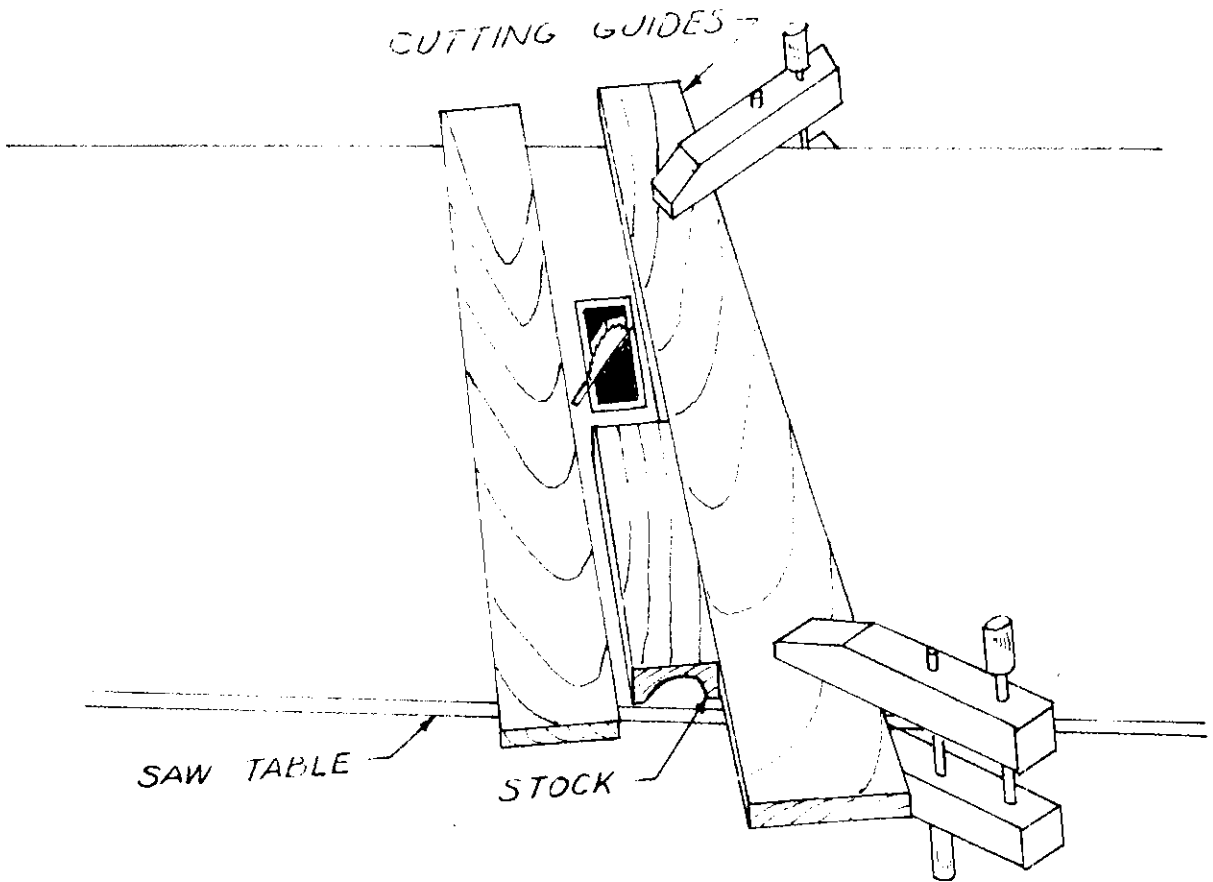


Fig. 13

Courtesy of H. Hjorth. *Machine Woodworking* (New York: Bruce, 1947), p. 73.

production operations but is satisfactory for small orders or special cases. In any event, it aids the operator in directing the stock over the blade at any particular angle. The nature of the cut itself results in a hazardous relationship between the machine and the material in that a stronger tendency exists for the saw to force the work piece away from the blade; in turn, a different relationship is created between the material and the operator if the guides are not present to counteract this force.

Although the operation consists of a series of small incremental cuts, the use of the push block as ordinarily applied to the jointer (Figure 25) is advisable in order to reduce the possibility of the operator's hand contacting the blade. In Figure 13, for clarity one guide is shown unclamped and slightly out of position.

Occasionally, machined pieces having irregular external contours or rounded contours require ripping cuts to be made on them, or other cuts made with special saw-type tools carried on the saw arbor. It is impossible to support such work in an ordinary way and at the same time, allow the required cuts to be made safely and properly. One of the best methods of handling such pieces, if they are sufficiently small, is the use of a special box type form designed to receive and hold them firmly while they are advanced to the saw blade.

Shown in Figures 14, 15, and 16 are operations as they are involved in making a special rounded form of drawer pull. Figure 14 indicates a round turning of swelled-center type which will make four drawer pulls of the kind under consideration. A retaining box (Figure 15) hinged at one end serves as a special purpose vice to cradle the



Fig. 14

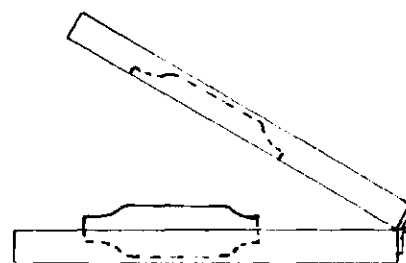
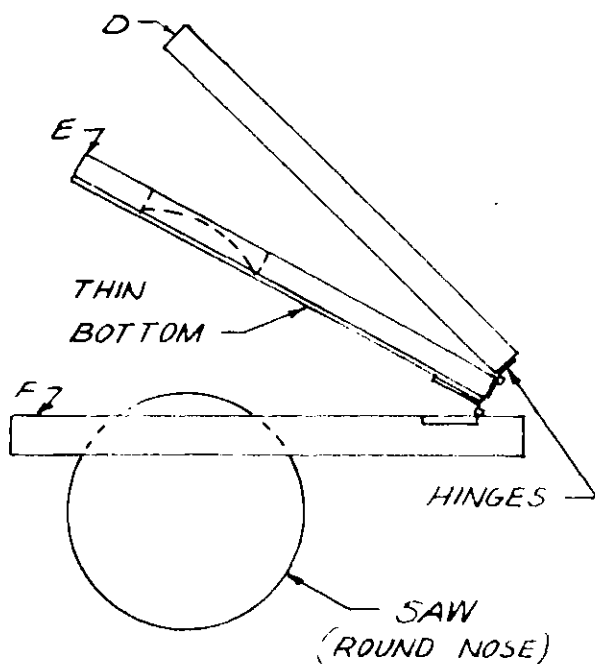
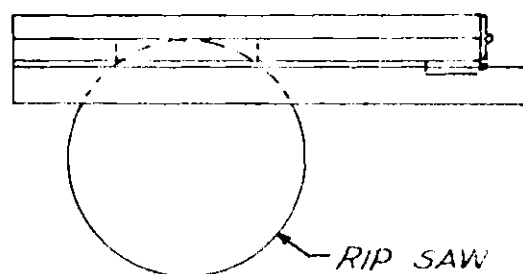


Fig. 15



A



B

Fig. 16

Courtesy of Williams Furniture Co.

piece as it is lowered over the saw blade for the splitting cut. In this manner, the work piece itself offers no danger to the operator; his chief concern is to handle the holding box safely. This, however, presents a hazard in that operator-control is easily lost due to the insignificant amount of resistance offered by the relatively small jig assembly.

In the succeeding hollowing operation, the same condition exists but to a less degree. The jig shown in Figure 16-A is more stable in that the base "F", which is mortised to receive the grooving tool, can be clamped to the saw table. Arm "E" also has a mortised slot with a thin bottom piece attached to contain the work piece during the cutting operation. Arm "D" serves as a cover to hold the half-round in position during the operation that cuts a groove the shape of which is indicated at "C" in Figure 14. Since all three arms of the jig are hinged together at one end, there is removed the possibility that the jig or the material will assume any uncontrolled state.

In Figure 16-B is shown the same jig and work piece but in closed position in preparation for the operation that will further reduce the wood turning to a quarter-round drawer handle. The conditions are similar to those in the preceding discussion except less force is exerted on the jig by the ripping blade than that developed by the grooving tool. Therefore, the reactional force required by the operator on the jig is considerably less in this instance, with the result that an otherwise hazardous exposure is replaced with a safe and efficient production method.

When the necessity arises to cut dadoes in quantity, some type of fixture is desirable to insure accuracy and safety. Such a fixture

may be quickly fabricated and will not only insure accuracy for the operation at hand, but can be readily adjusted for any future dado work.

In Figure 17 is shown a fence attached to a cross-cut guide. The fence is grooved its full length to accomodate the spring finger stops as illustrated. In ordinary use, the cross-cut guide serves to maintain the stock in a square, true position. Production is improved through the use of finger stops spaced in the fence at intervals equal to the distance between anticipated dado cuts. Because of their design, the fingers spring out as the end of the stock piece passes each one. A dual purpose is served by this feature whereby the finger at the end of the stock acts as a locating stop block; also as a rest against which the operator is able to exert a portion of the force necessary to hold the work piece in proper position relative to the dado blade. To counteract peripheral force of the saw blade, an auxiliary hold down is provided as shown in the illustration. By use of this method, the operator's hands are restricted from the critical machine point of operation.

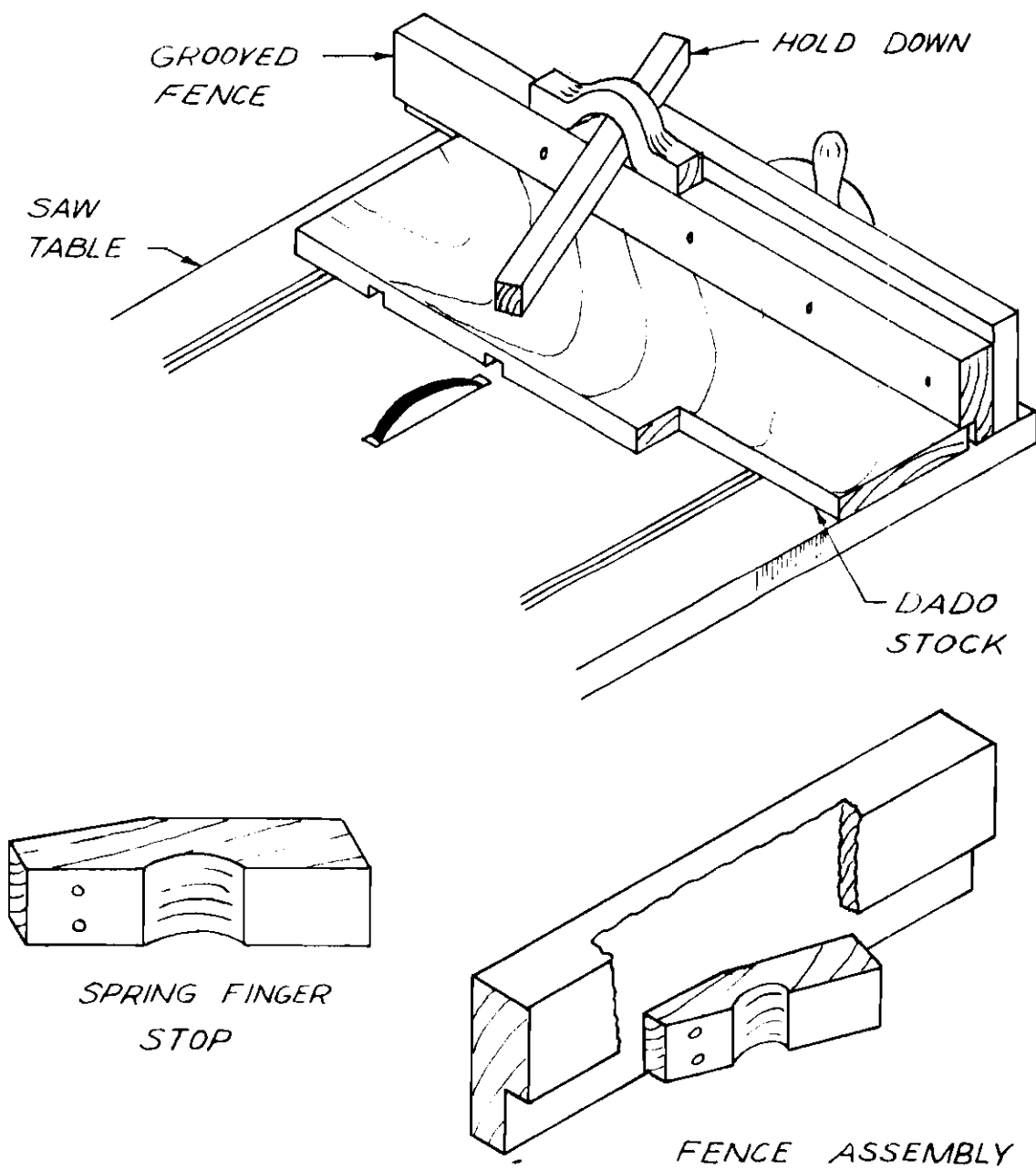


Fig. 17

Courtesy of Baldwin Piano Co.

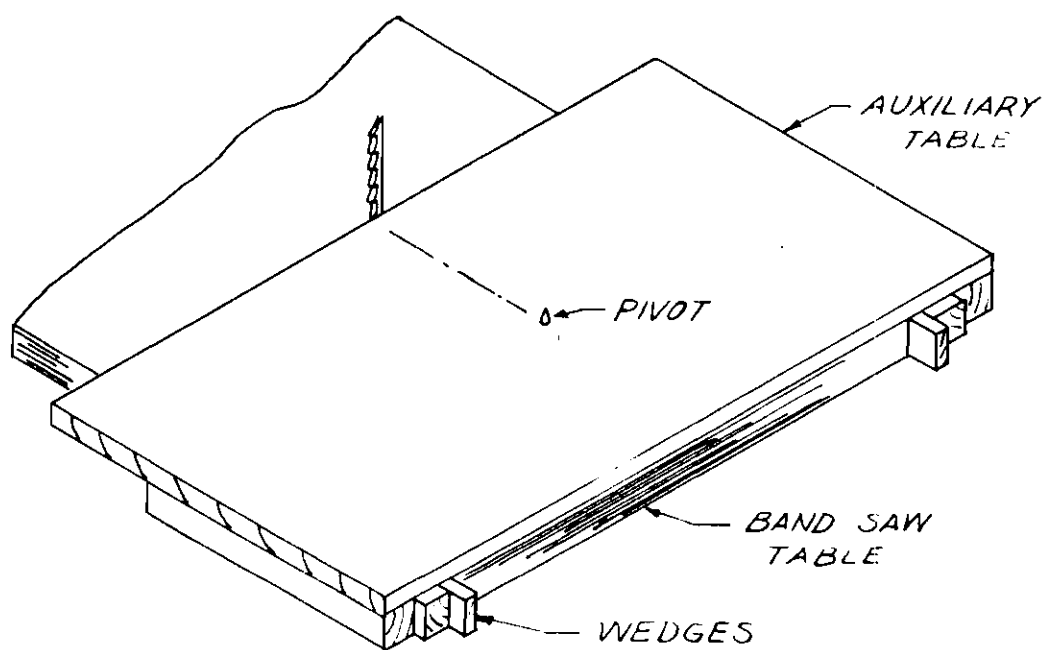
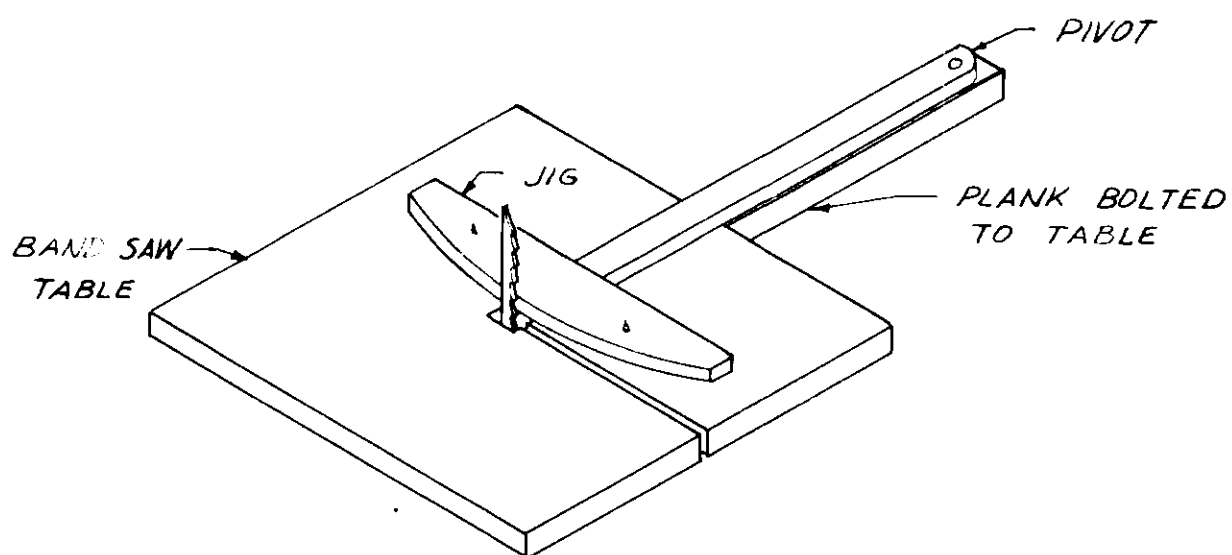
THE BAND SAW

Another machine in the furniture industry which has various uses is the band saw. Like the table circular saw, it presents several hazards to the operator, but to a somewhat less degree. There is still the presence of moving blades that cannot be readily stopped in case of an emergency; however, it is not as dangerous as the table circular saw. This is due chiefly to the slower speed at which the band blade travels, and to the smaller size of its teeth, both in depth and thickness. Due to these characteristics, there is not as much tendency for the saw to seize the stock from the operator's hands except in cases of a tilted work table. Even so, there are several situations in which the use of jigs and fixtures appears to be justified.

A number of circular disks or segments may be sawed automatically without marking the stock if an auxiliary plywood table is placed on the saw and wedged into position as shown in Figure 18. This method of attachment renders it free from all obstructions.

A center or pivot for the disk is provided by a screw inserted through the bottom of the auxiliary table. As a stock piece is pressed over this screw point, it can be turned in a complete circle, resulting in a perfectly round disk with no danger of the stock slipping in any lateral direction. The motion of the blade in a downward direction serves to hold the stock well in position in the vertical plane. The operator then is spared any possibility of injury to his hands due to this self-guided operation.

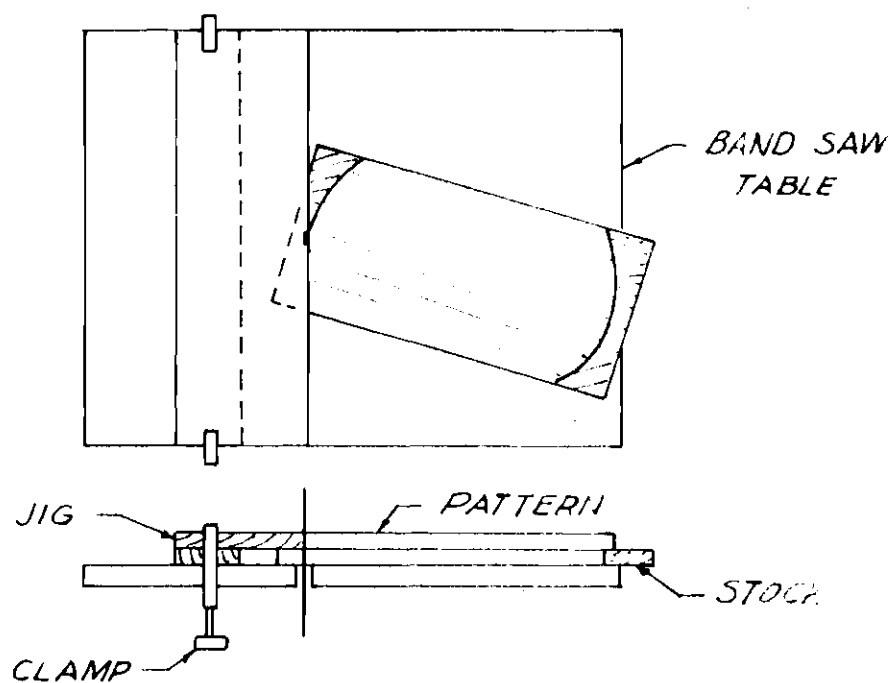
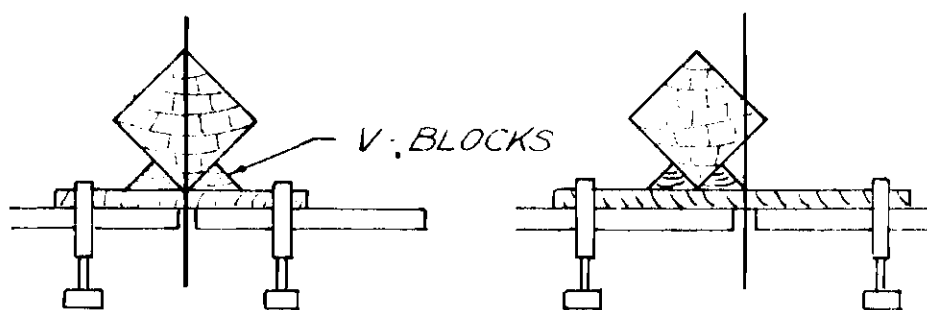
Segments of circles from larger stock are used in making large arcs for some types of products in which the center pivot may lie

*Fig. 18**Fig. 19*

Courtesy of Williams Furniture Co.

outside the band saw table. In this case, an extended arm is arranged as shown in Figure 19 with the pivot located in a line perpendicular to the teeth of the saw blade, similar to that of the preceding illustration. A model of the segment to be made is mounted on the arm and pivoted with a dowel pin in such a manner that the curved edge of the segment touches the saw blade at all points as it swings through its arc. Two screws inserted from the underside of the jig segment serve as spurs to hold the stock in place while it is being cut. Here again, the hazards to the operator are minimized due to the controlled radial motion of the stock piece and the downward action of the saw teeth.

A number of pieces with straight or irregularly curved edges, either convex or concave, can be cut on the band saw in a manner similar to that described for the circular saw (Figure 12). A jig is readily made by using a guide piece of one inch board clamped to the saw table as illustrated in Figure 20. It is necessary for this piece to possess the same contour as that of the work to be cut, and to be notched in order to receive the saw blade flush in its edge. From the figure it is seen that a piece of wood slightly thicker than the stock to be cut is clamped under the guide piece to allow space for the stock to slide underneath while the pattern rides the edge of the guide. Steel spurs in the pattern serve to hold the stock in position while the cut is being made. Since the edge of the pattern is held against the notched edge of the jig while the projecting parts of the stock are left underneath, the operator may make the cut safely because the stock is kept in rigid position throughout the operation due to the guiding action of the jig in the horizontal plane, and the downward force

*Fig. 20**Fig. 21*

Courtesy of Baldwin Piano Co.

exerted by the operator's hands against the protruding spurs. It is important to note, however, the possibility that waste pieces can accumulate under the jig and clog the band saw throat or deflect the pattern.

Often there arises the necessity of sawing triangular pieces of stock length-wise, or cutting the corners off of square stock as a preparatory operation to ready the stock for lathe turning. If work of this nature is attempted by the operator without the use of any type of holding device, trouble is likely to develop because of the natural tendency for the stock to assume a flat position on the table. The downward motion of the saw blade again becomes an important factor due to its inclination to force the stock on its side. This situation exposes the operator to the possibility of having stock twisted from his hands unless very small cuts are made. In this type of operation, a jig such as is shown in Figure 21 is useful. It consists of a board to which two triangular pieces are glued or nailed, forming a cradle in which the square or triangular stock is held to the desired position. As a result, the stock is prevented from turning about its longitudinal axis during the procedure. The operator's only other concern in this case is the rate of feed because the reaction of the saw blade aids him in holding the stock to the jig cradle. Many other angular cutting operations can be accomplished safely and conveniently with this type of jig while the table is retained in the more desirable horizontal position.

Where very large lots of material are to be worked, multiple sawing can be done on the band saw. In some instances operators become

more or less adept at simply holding two or three pieces properly stacked for sawing, while only the top piece is marked. As a general rule, however, that is not very satisfactory on work requiring accuracy because the slightest amount of slippage between any two pieces naturally reduces the accuracy of the cut.

There are several ways in which multiple pieces may be held together while band-sawing. They may be nailed in such a manner that the nails are driven through the portion to be removed later by the saw. Another method is to bore holes and insert dowel pins through the bored holes. These dowels are left in place until the sawing is finished and then they are removed.

Shown in Figure 22 is a method of holding certain types of work for scroll sawing in multiple. It consists of framing the pieces to be cut inside an embracing box-type structure. Where this method is used it is very important that the stock fit with a snug push-fit inside the box. Such a box either may or may not have a bottom; if the stock is very large in size, a bottom is preferable to lend additional strength.

In addition to improved production, the use of this jig contributes considerably to the safety of the operator in that the pieces cannot slip apart from each other; in which event his hands could possibly be drawn into the moving blade.

In cutting curved pieces requiring parallel edges such as table legs and chair legs, a holding device is almost a necessity. In Figure 23 is shown such an appliance known in the furniture industry as a "sweep jig". Since it is used to make long, curved cuts demanded by

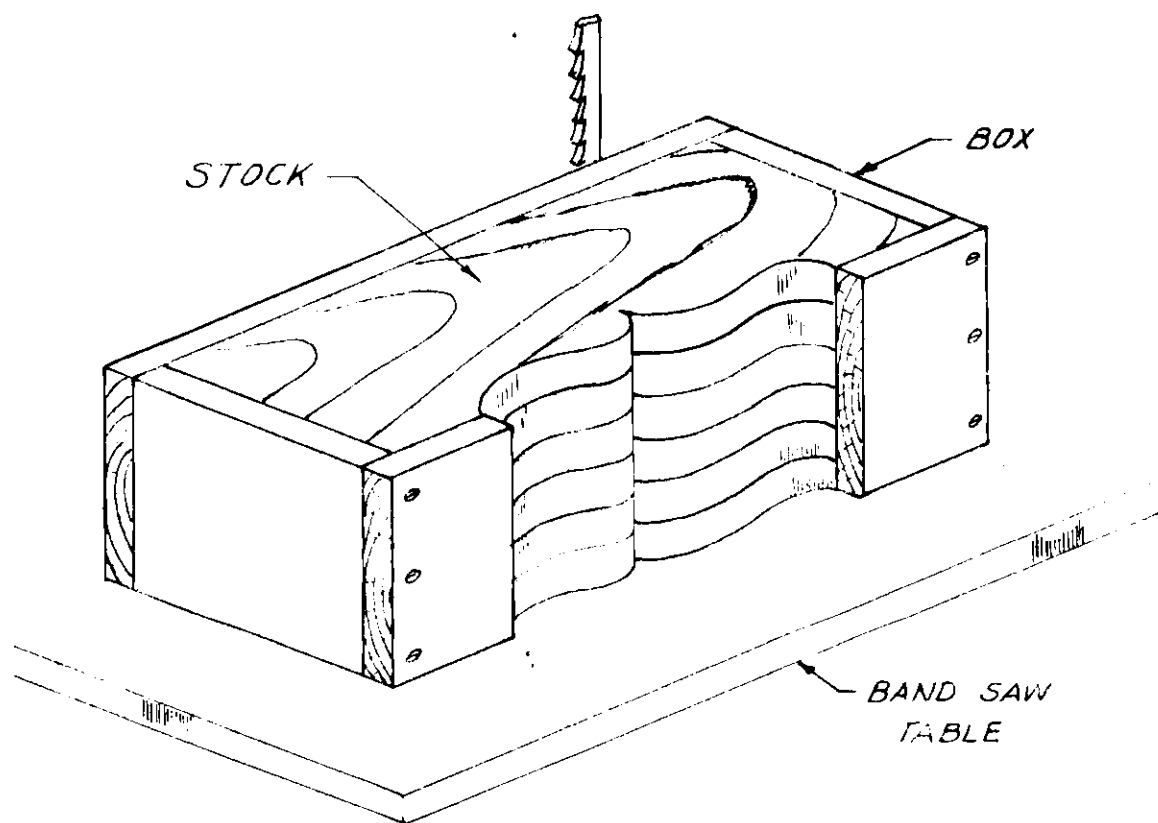


Fig 22

Courtesy of *The Woodworker*
Magazine 65: 40 Dec: 46

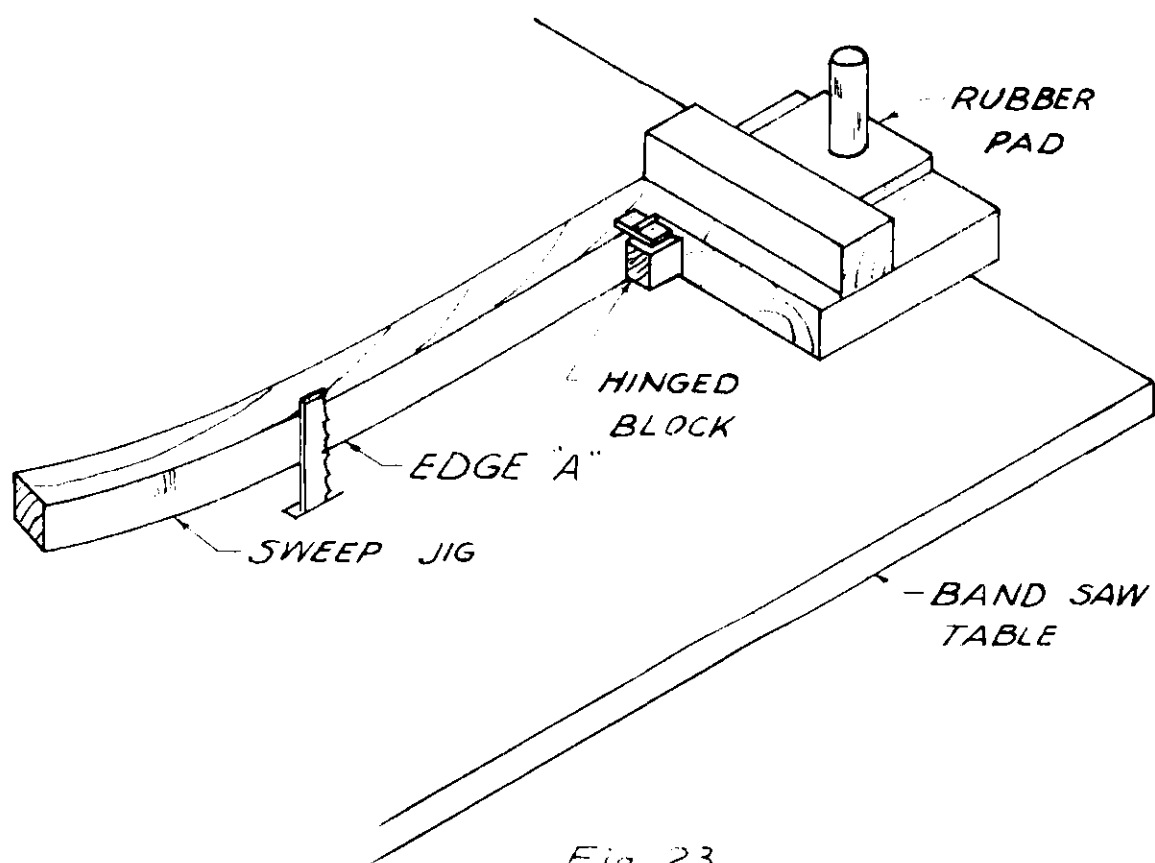


Fig. 23

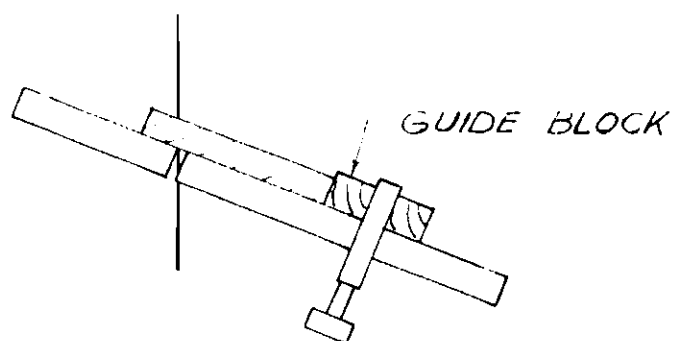


Fig. 24

Courtesy of The Mangel Co

furniture leg pieces, it is valuable to the operator in that a continuous cut can be made as the stock rests against edge "A". Its designers felt that it would enable the operator to make a large number of accurate cuts and at the same time accomplish this safely; the most important safety feature being to permit the full length of the leg to be passed through the saw in one sweep. This eliminates the necessity of the operator removing his hands to obtain a new grip as the following end of the stock reaches the saw blade. Consequently, the possibility that he will come in contact with the blade is reduced and a faster, more efficient operation is made. Furthermore, due to the unusually thick and hard grained stock normally involved in this procedure, there results a great amount of reaction in the stock to the force exerted on it by the saw blade. The jig illustrated serves to aid the operator in holding the stock in place while the horizontal motion is in progress. It is also noted that a rubber pad is used as a hand rest to aid the operator in meeting the reacting force of the machine. The small hinged block serves as a quick change-in-length adjustment to compensate for the difference in length of front and rear chair legs, for example.

Another operation that sometimes arises for the band saw is beveling or chamfering. When this is the case, one method that is used to advantage is to tilt the band saw table if its type of construction permits.

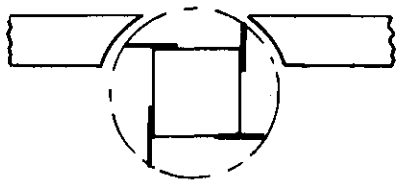
After the table is locked in the desired position, the work is passed through the blade. It is important here that the operator takes care to hold the stock to the right of the blade; i.e., on the part of

the table which, in tilted position, is below the blade (Figure 24).

If held on the upper portion of the table, the stock bears against the blade, offering the possibility that the stock will inadvertently slip into cutting position. To ward against this circumstance when a straight cut is to be made, the work can and should be guided on the ripping fence or on a guide clamped to the table. This reduces the possibility that control of the stock may be lost during the cut.

THE JOINTER

In considering hazardous operations of woodworking machines, the jointer or buzz planer occupies a dominant position. The greatest exposure of this machine, so far as production is concerned, is the large cutting blades it uses. From the safety point of view, jointers of today are equipped with guards of various types but the protection they afford the operator is far from complete. The machine is built such that the large revolving knife blades produce a thrust, the strength of which is forceful enough to wrest the stock from the operator's hands if a sufficient amount of force downward and forward is not maintained. This is especially true in certain procedures involving the machining of short, narrow stock which tends to tilt into the opening in the machine table. A magnification of this characteristic is present on machines having the rarely used square cutter head. Since the blades are mounted against the four sides, a more hazardous condition is presented by the increased distance from the outside edge of the blade to the cutter head (Figure 25-A). From Figure 25, it is noted that the cylindrical cutter head, with its blades mounted almost tangent to the surface, offer a much smaller area into which the fingers would enter in the event that the operator's hands were drawn into contact. Even if the stock is held firmly with the hands, there arises the possibility that, for example, an existing fault such as a knot or decayed area could cause the piece to be seized from the operator, resulting in lost control of the material and of the hands as well. Therefore, due to the tremendous amount of tangential force resulting from the powerful thrust of the machine, it behooves responsible



SQUARE TYPE HEAD

Fig. 25-A

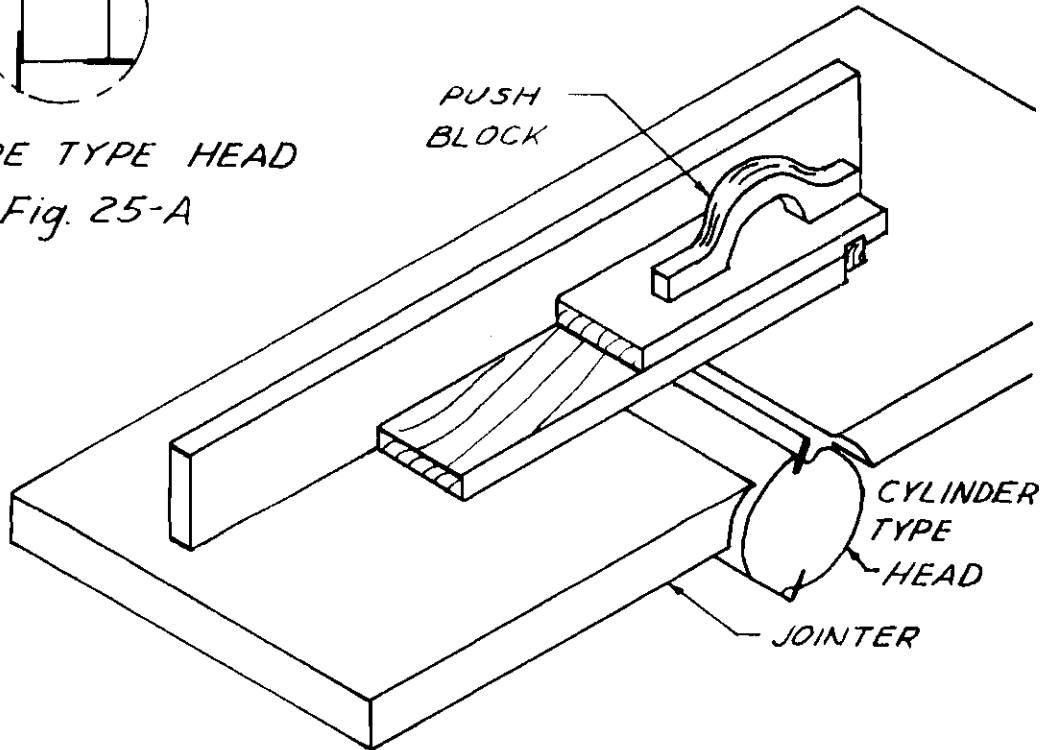


Fig. 25

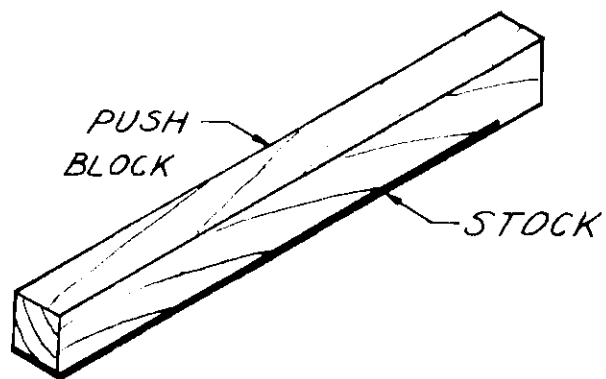


Fig. 26

Courtesy of Williams Furniture Co.

personnel to provide and insist on the use of adequate jigs and fixtures wherever feasible.

A push block (Figure 25) is a jointer jig in its simplest form. It has proven to be indispensable for the face planing operation, especially on short pieces, due to the additional rigidity it provides by permitting the operator to apply a more positive downward force on the work during its horizontal travel over the cutting knives. At the same time, the distance between the operator's hands and the danger area is increased, thereby reducing the possibility of hazardous man-machine contact. It is noted that the small inserted stop guide at the rear of the push block maintains the proper relative position of stock and jig throughout the cut. For lateral security, the jointer fence provides a dependable aid to proper machining. An important precautionary measure of planing with the grain rather than against it is further assurance of a successful operation.

Another variety of push block is shown in Figure 26. This type is used as a backer for safely jointing thin stock such as that used in T-square blades and veneer face pieces.

The edges of veneer can be machined on an ordinary jointer if they are held between the sides of a special clamp consisting of two pieces of hardwood bolted together (Figure 27). The jaws of the clamp are shaped convexly to assure a positive holding action on the veneer sheets. Although the jig provides a simple and convenient method for this operation, it does not lend itself favorably to high production because of its limited stock capacity per cycle. It is also evident that the device could be improved by the addition of hand grips or some

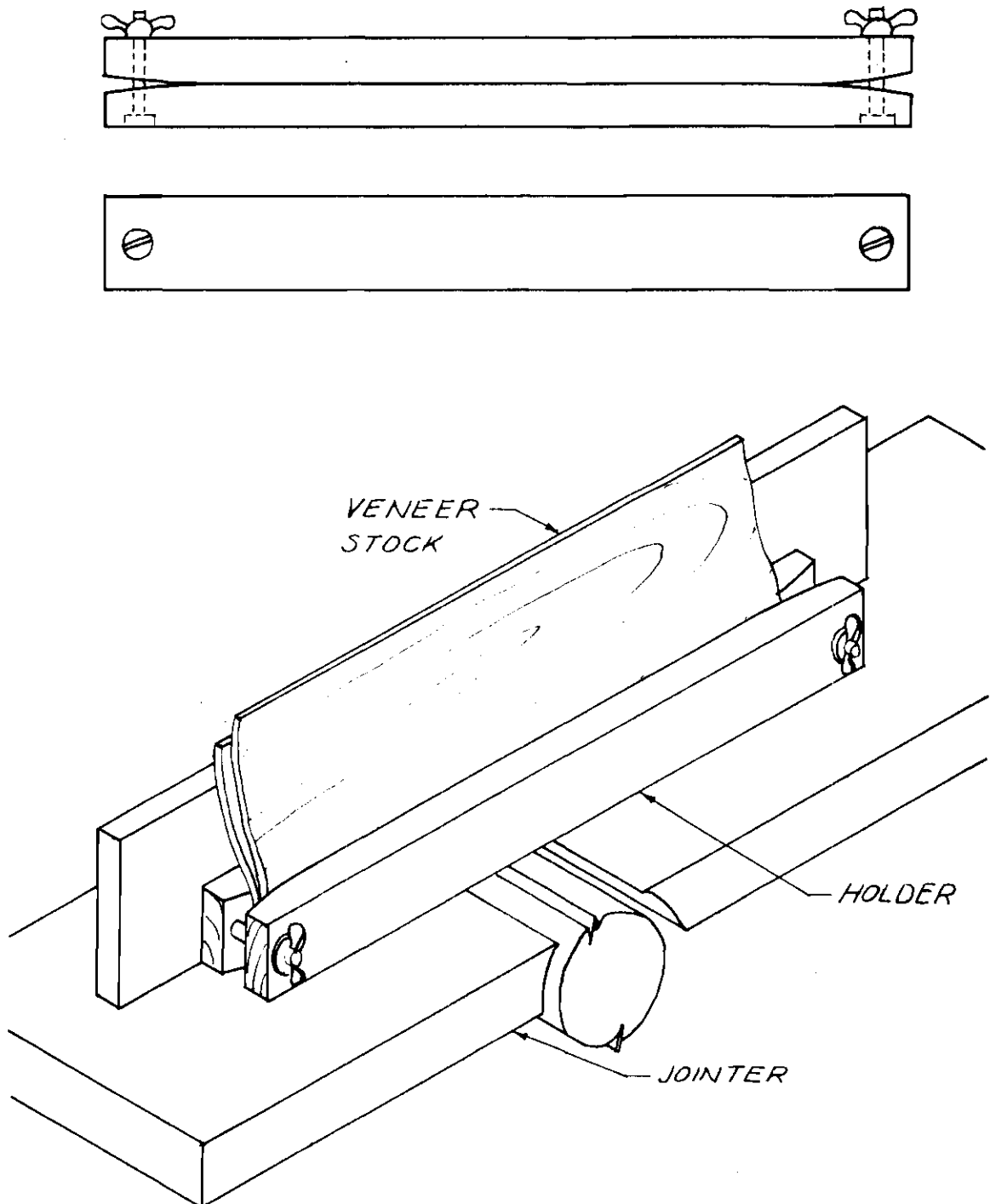


Fig. 27

Courtesy of H. Hjorth, *Machine Woodworking* (New York: Bruce, 1947), p. 85.

other type of handle to increase the distance between the point of operation and the operator's hands. This condition could also be remedied by the use of wider material in order to give the jig more height. Since the cut involved in this operation is of the edging variety, and because the stock is thin, the man-material relationship is not so prevalent as that between the man and the machine.

An occasional operation arises in woodworking shops requiring some forethought and experimentation before the best way to do the work can be found. In Figure 28 is shown a sample of the end to be machined. Obviously, a jig is required to hold the heavy stock at the proper angle while it is passed over the blade for a very rigorous, end-grain cut. With these conditions in mind, the jig illustrated was designed for the specific purpose of holding the work piece at the desired angle by means of the two fixed, inclined supports. When the stock is clamped to the top support, the end to be machined rests on the infeed jointer bed, and held against the bottom support by a force exerted by the operator in a direction perpendicular to the inclined surface. The jig is entirely self supporting; the base consisting of two pieces with offsets cut on the lower edges to compensate for that between the front and rear jointer tables. Care is taken never to run the jig completely across the cutting blade in order to preserve the offset in the base runners. By using this method, the stock is easily held in place as the entire assembly is pushed through the cutting cycle, resulting in the reduction of exposures offered by operator-material contact, and an appreciable reduction of hazardous operator-machine relationships.

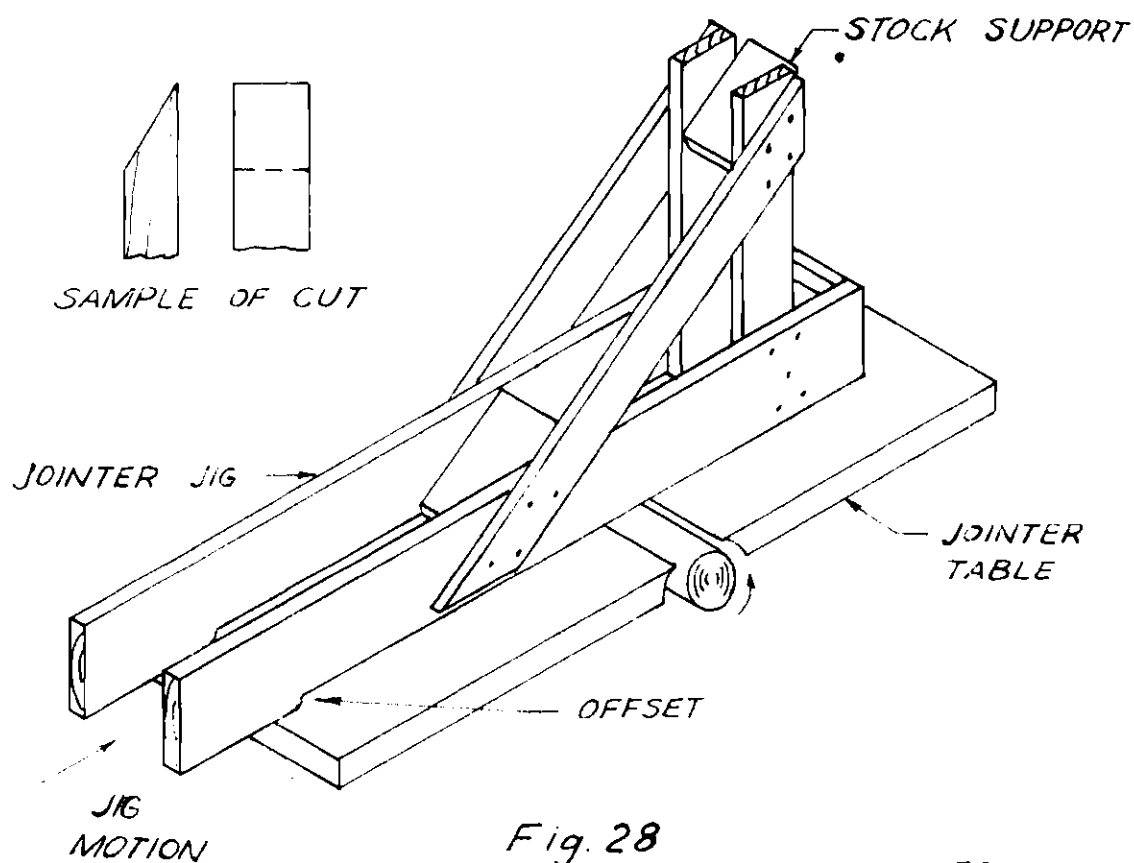


Fig. 28

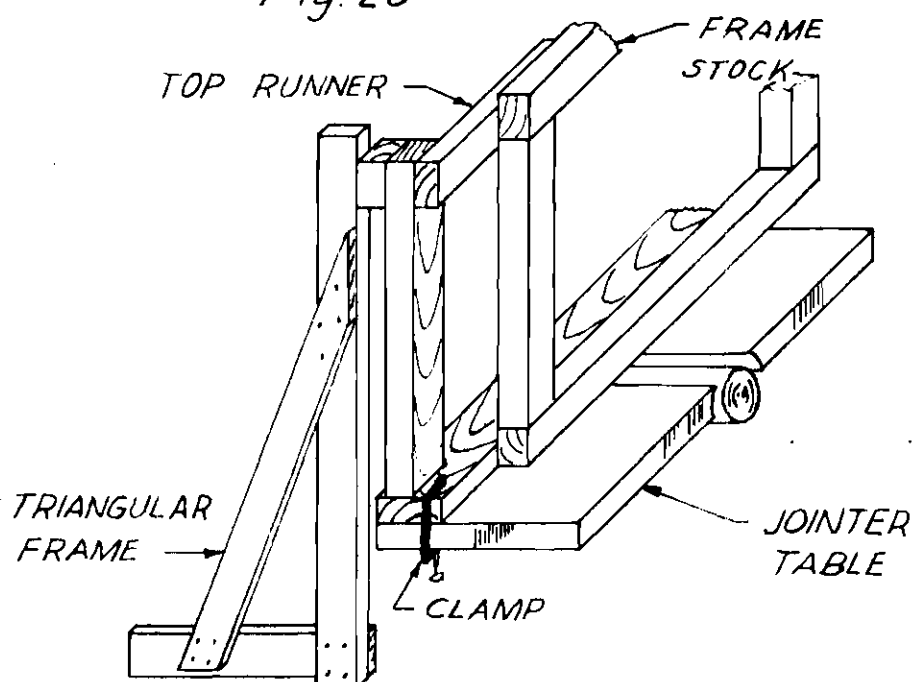


Fig. 29

Courtesy of Baldwin
Piano Company

Men who have jointed heavy, wide frames or other such stock know that it is difficult to give proper attention to the progress of the cut and at the same time, balance the material to prevent its rocking from side to side. In some shops, when work of this nature is to be done, it is not uncommon to make a two man operation out of what could otherwise be readily performed by one man. The standard jointer fence seldom gives more than a six inch bearing surface for the stock, and in case of frames, even this much can not be utilized because the stiles and rails are usually narrower than six inches.

With the jig shown in Figure 29, the operator is able to place a heavy frame on the jointer table, allowing the two stiles of the frame to bear on the spacer runner and lower clamping member. Therefore, if a mild amount of pressure is exerted "fenceward", as in ordinary jointer practice, the heavy frame is jointed and handled safely by one man. Due to the large relative size of this type stock and the usually small amount of cut, the possibility is slight that control of the material will be lost by the operator. Furthermore, the same factor of stock size reduces the amount of operator-machine relationship by virtue of the inherent distance present between the holding position and the point of operation. In the event of wide, solid stock, the frame will be equally efficient if the material is wide enough to reach the top runner.

If desired, a second runner like the top one can be run across the frame at a lower point to accommodate somewhat narrower stock. Such a fence is actually more efficient than a solid one of the same height because the surface contact is limited; therefore, frictional

resistance to feeding the stock is less. This condition also reduces the possibility of the operator's feet slipping on the floor, causing him to fall into the revolving cutting head.

The arrangement as described is designed for jointing material square; with a few minor changes, it would be entirely possible to modify the arrangement to handle beveled material just as safely.

THE SHAPER

The hand-feed woodworking shaper is known to be a machine of high versatility. In this connection, it is interesting to observe that this natural characteristic has been augmented greatly by the development and use of various jigs, fixtures, and attachments.

Even with its many uses, however, the fact cannot be overlooked that it is also a machine possessing many hazards of varying degree. The high rates of speed at which the cutter head travels presents a constant hazard to even the skilled operator. Consequently, the shaper has received much attention with emphasis being placed on methods of holding the stock in position while it is being machined. The need for increased production and higher quality of work is the secondary reason responsible for this consideration.

Pieces of material having an irregular outline, and which require molding or otherwise working over the entire edge are very often placed on an outline form which is made to the finished size and shape the work is to be. Then, by setting a pair of shaper cutters properly, the outline form can be run against a guide collar and the piece of material shaped in its entirety along the edge. The form used is usually of hard wood in order to resist wear. This is feasible in the case of any stock shape that is to be duplicated repeatedly. In some instances where the cut to be made is relatively light, such outline forms have simple spur points on their work-contact face, on which the stock is tapped down with a mallet to prevent its slipping during the cut. In some cases, a hold down is arranged to exert pressure downward on top of the stock being handled, and thus hold it firmly to the form.

In other instances, outline forms may be equipped with some type of clamp or other device to hold the material to the form; in fact, clamps for shaper forms are commercially available. It follows then that any outline that can be incorporated into a form can be readily produced on a work piece that is held on top of that form. This gives scope for a tremendous range of work, for while the working edge of the outline form will be square, a section through the edge of this piece produced may be anything one desires.

There are various types of turning cuts made at the shaper which may or may not incorporate a molding or something other than a square edge. It is noted that for this type of work, special attachments are used on the shaper that will allow such work to be machined with safety.

One of the characteristics of the ordinary shaper that is responsible for a large portion of its utility is its adjustable, two piece fence. Front and rear halves are independent of each other and can be bolted to the table top in several positions.

This machine, with its cutter spindle speed ranging from 7,200 R.P.M. to 10,000 R.P.M., is capable of producing countless types of forces in as many directions, depending on such factors as the number of cutters mounted on the spindle, their shapes, the type of material being cut, the feeding speed of the material, the depth of cut, and others. It is known, however, that the principal item to be considered from the jig and fixture point of view is the tangential force produced when the workpiece makes contact with the cutter head. Since the shapers to be discussed in this treatise are all of the vertical spindle variety, it follows that this predominant peripheral force

occurs in an infinite number of planes parallel to the shaper table top. The chief function of a jig or fixture becomes one of absorbing or reacting to this force with an amount of counter-force sufficient to maintain the intended controlled relationship between the operator, the machine, and the material.

In Figure 30 is shown a simple method in which the principal horizontal force and a secondary vertical force are restrained by use of attached spring clamps which are accessories to the shaper in this instance. Because of the reacting components of the fence and the table top, the only other force exerted is that which is necessary for the operator to push the work piece through its cutting path.

When the stock is wide enough to be held with the hands, an auxiliary guide piece can be clamped to the table (Figure 31) in order that the pointed end bears against the collar and clears the underside of the knives. As the stock is moved toward the cutter, the guide piece serves as a fence to react to the applied force of the operator. The shaper collar then acts as a guide from the time the stock makes contact with it until the operation is completed. A steel pin screwed into the table top may also be used instead of the wooden guide, but the latter offers the advantage of serving also as a chip breaker.

When the stock is veneered, or is of the type that is likely to tear out at the edges of a groove or a rabbet, the guide piece is placed in a slightly different position (Figure 32) providing only a 1/16 inch cut is made at the first passing. It is then placed as shown in Figure 31, and the cut is finished to its full depth at the second passing. This "stage cutting" process also provides safety to the operator by eliminating excessively large, hazardous cuts.

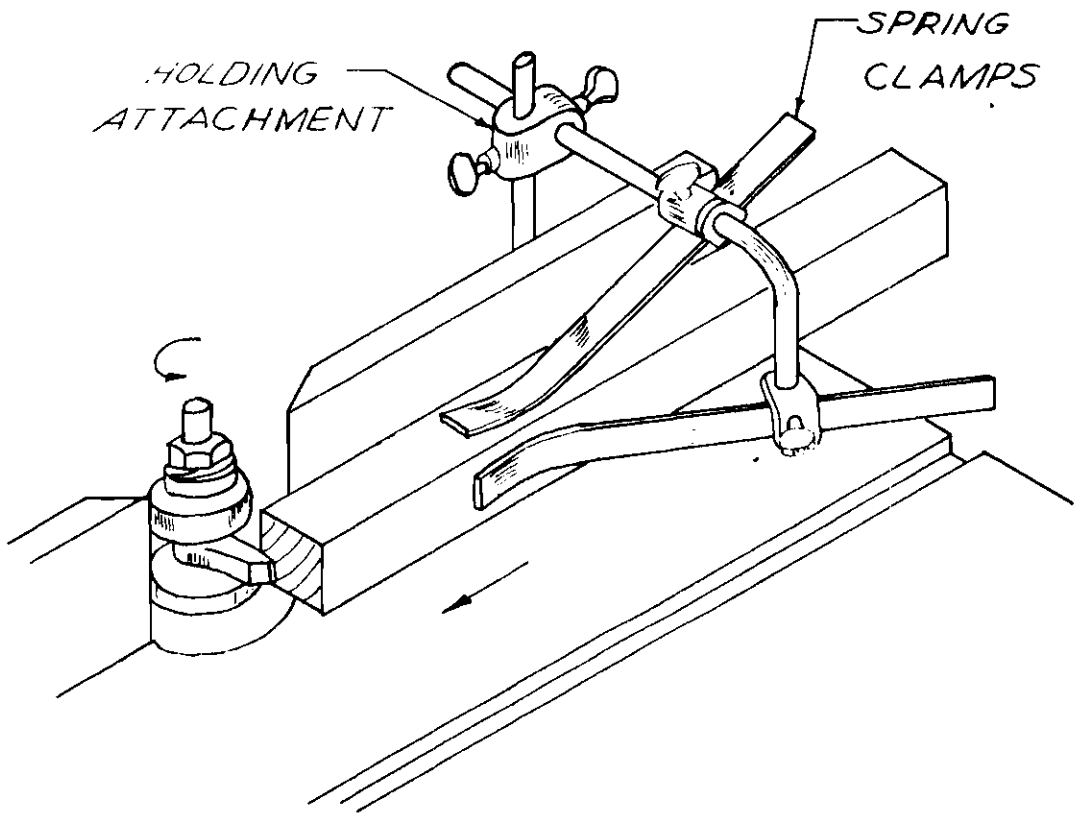


Fig. 30

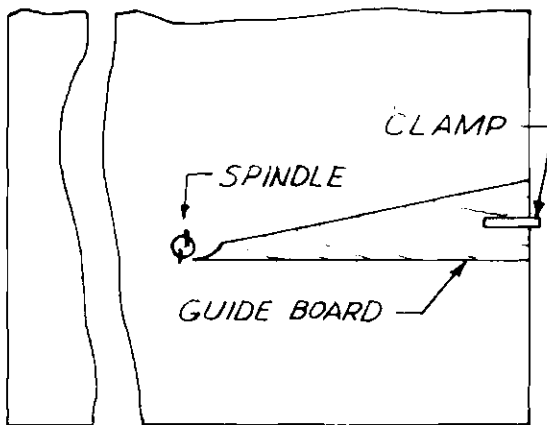


Fig. 31

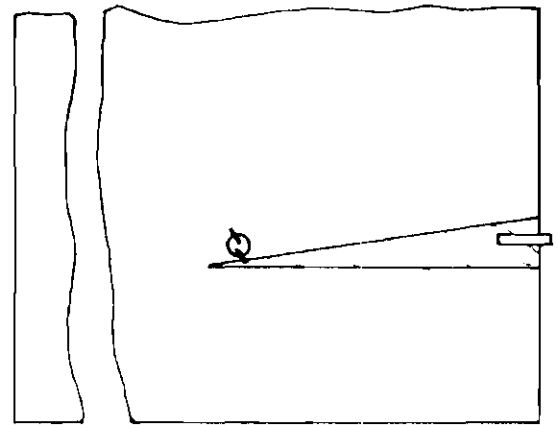


Fig. 32

Courtesy of H. Hjorth, *Machine Woodworking* (New York: Bruce, 1947), p. 91.

When beveled stock is to be worked to uniform width at the same time its edge is shaped, the arrangement shown in Figure 33 is convenient, in which case, the beveled edge bears against guide board "A" clamped across the table, but not against the spindle collar. The contacting edge of "A" is also beveled to match that of the work piece, thereby partially functioning as a hold down, as shown in the cross sectional view. Another guide board "B" is clamped to serve as a spring exerting a lateral pressure against the edge of the stock to be worked. This spring board and guide board "C" are further supported by additional clamped members "D" as shown. A combination guard and hold down (not shown) is also used in front of the cutter.

On straight stock, reeding and fluting is done like ordinary shaping of straight edges. On turned work, a special jig (Figure 34) for mounting the stock resembles the headstock and tailstock of a lathe mounted on a base. After the cutters of the correct shape are attached to the spindle, the stock is guided through the blades as the pre-formed base follows the shaper collar. By this method, the round stock is prevented from rolling and a uniform depth of cut is maintained. The template shaped base is especially valuable when reeding or fluting is not continuous from one end of the turning to the other. In such cases, the template is profiled in a manner to automatically move away from the knives any segments that are not to be cut.

It is often necessary to bevel or miter the edges of material for such work as columns, taborets, etc. A jig (Figure 35) resembling a guide for straight work can be useful, and yet is simple. It consists of two guide runners hinged together, one of which is attached to the

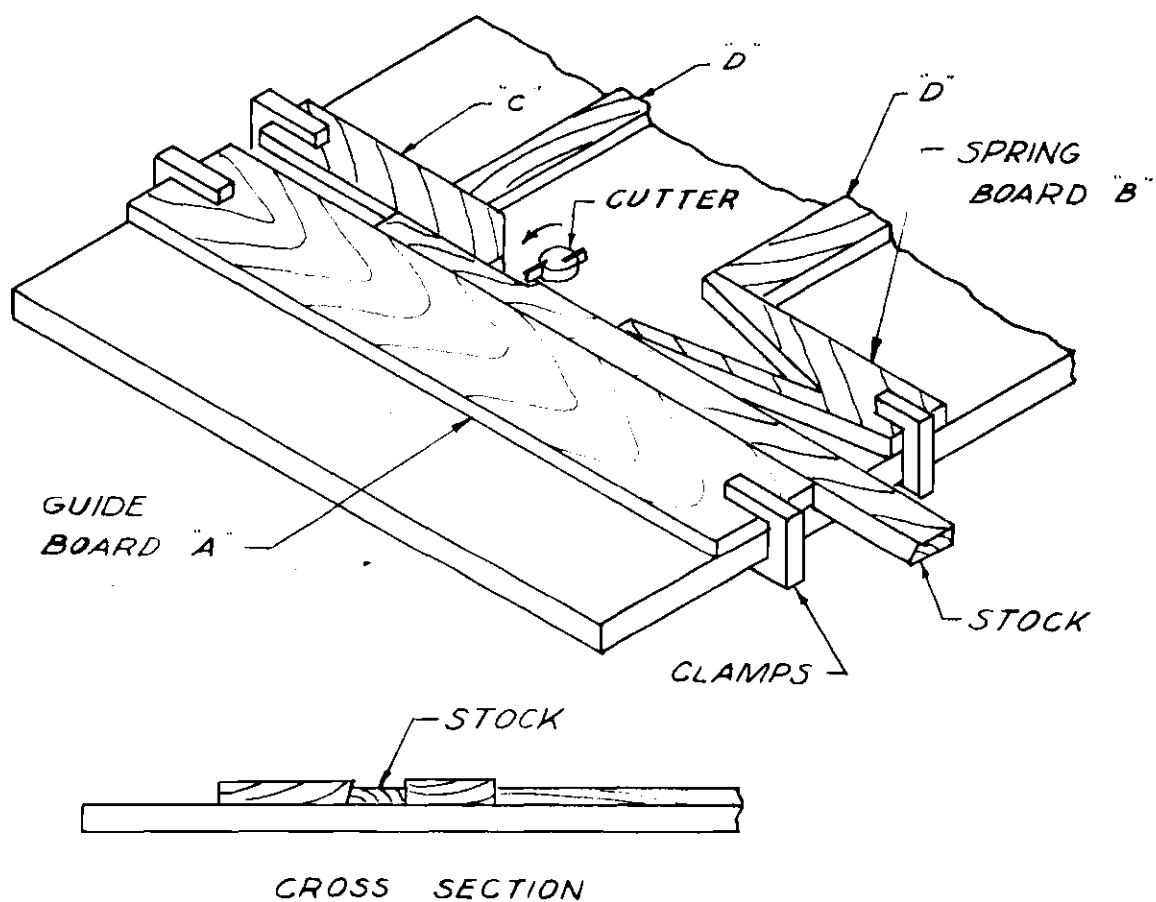


Fig. 33

Courtesy of Williams Furniture Co.

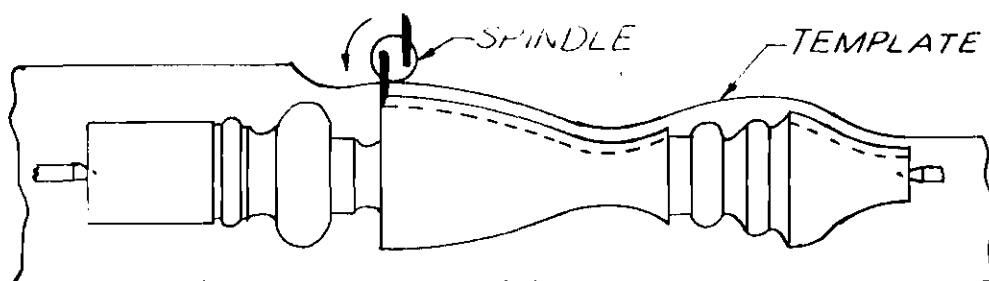


Fig. 34

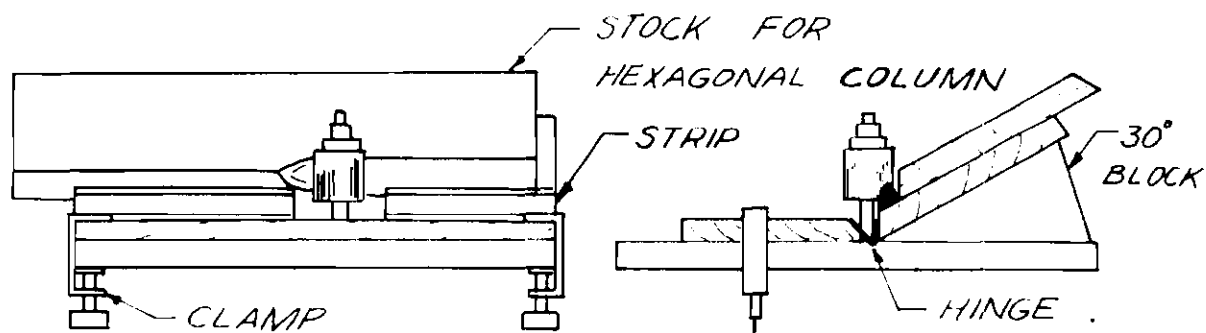
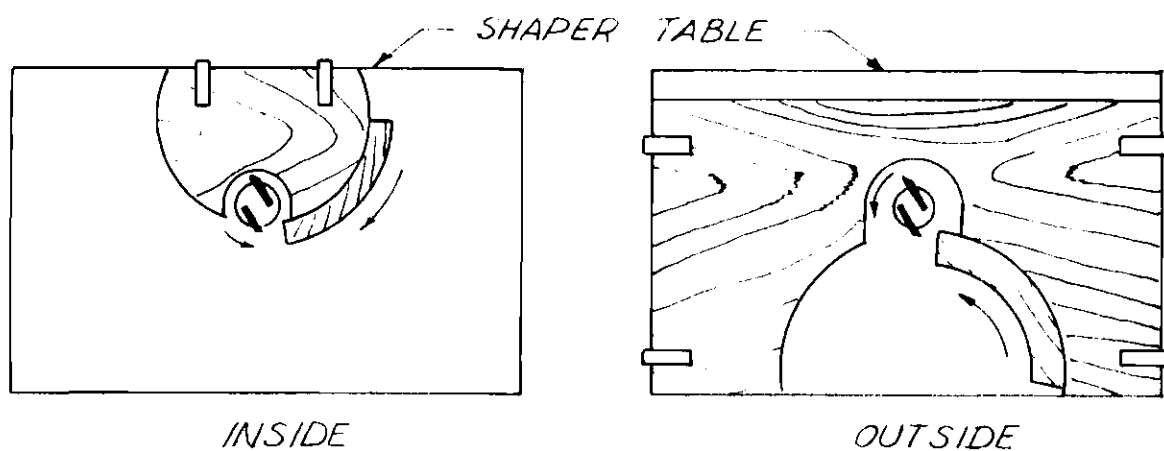


Fig. 35



SEGMENT GUIDES

Fig. 36

Courtesy of Williams Furniture Co.

shaper table while the other is raised to a desired angle by means of blocks fastened to its underside. An opening is cut in both members through which the shaper head protrudes, and then a cleat or hardwood strip is attached to the inclined runner. This serves as a guiding support while the stock is passed over the knives. Although there is a considerable amount of exposure to the operator's hands during this procedure, the size of the jig and the guide-way offer ample protection if precautionary measures are taken to exert the required forces in a direction parallel to the runners and perpendicular to the inclined surface. During the second passing of the stock, a groove is cut (not shown) for a spline with a small saw mounted on the adjacent spindle. The same precautions also are necessary due to the similarity of the two operations.

To make guides for shaping the inside and outside edges of a circular segment, a plain, flat board which has an opening for the shaper head is clamped to the table as shown in Figure 36. It is essential that the radius of the guides and that of the segment be exactly the same in order to maintain the proper smooth contact between them during the operation. If the entire edge of the segment is to be processed, the left side of the guide should be proportionally larger in order to properly support the work throughout the cutting cycle. To further insure a safe procedure, the forces applied by the operator are most advantageous if they are at all times applied in a plane parallel to the table top and in a direction toward the center of the radius where the contact surface is an inside radius; away from the center if the contact surface is an outside radius. It is also im-

portant to note in the illustrations that the motion of the work segments is always opposite to that of the shaper spindle; a condition which tends to cause the forces of man and machine to counteract each other.

When the edges of discs or circular table tops require shaping, they can be readily supported at two points by the guide shown in Figure 37. Similar to the operation discussed in the preceding paragraph, the stock piece is directed in a motion opposite that of the cutter blades while sufficient downward pressure is exerted by the operator. Due to the close proximity of the hands to the blades, care is in order that the work be handled at points diametrically opposite the point of operation. It is also seen that this guide can be used for disks of various diameters, but not for segments because only one point of contact would exist at the beginning and end of the operation.

Also in a similar vein, the same type of work pieces can be made perfectly round and receive shaped edges simultaneously with the use of the pivot guide (Figure 38) which is similar to the one designed for the band saw, previously illustrated in Figure 18. For this use, however, it is advantageous for the guide board to extend across the shaper table. In addition, an oval shaped hole is necessary to receive the shaper cutter and allow for adjustment in either direction, also facilitating any diameter that might be obtained within the capacity of the machine. Due to the use of the pivot, the operator is relieved of a certain amount of personal attention to the machine. However, here again is a procedure that merits his precaution; first, because of the force he is required to exert around the circumference of the

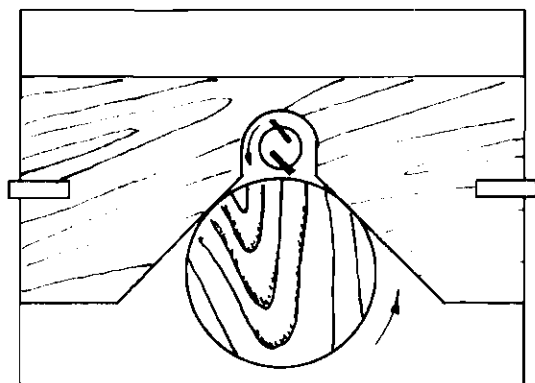


Fig. 37

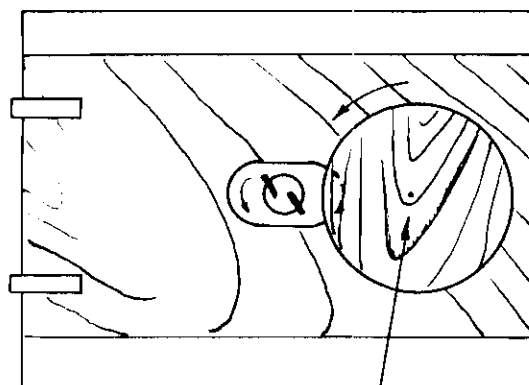
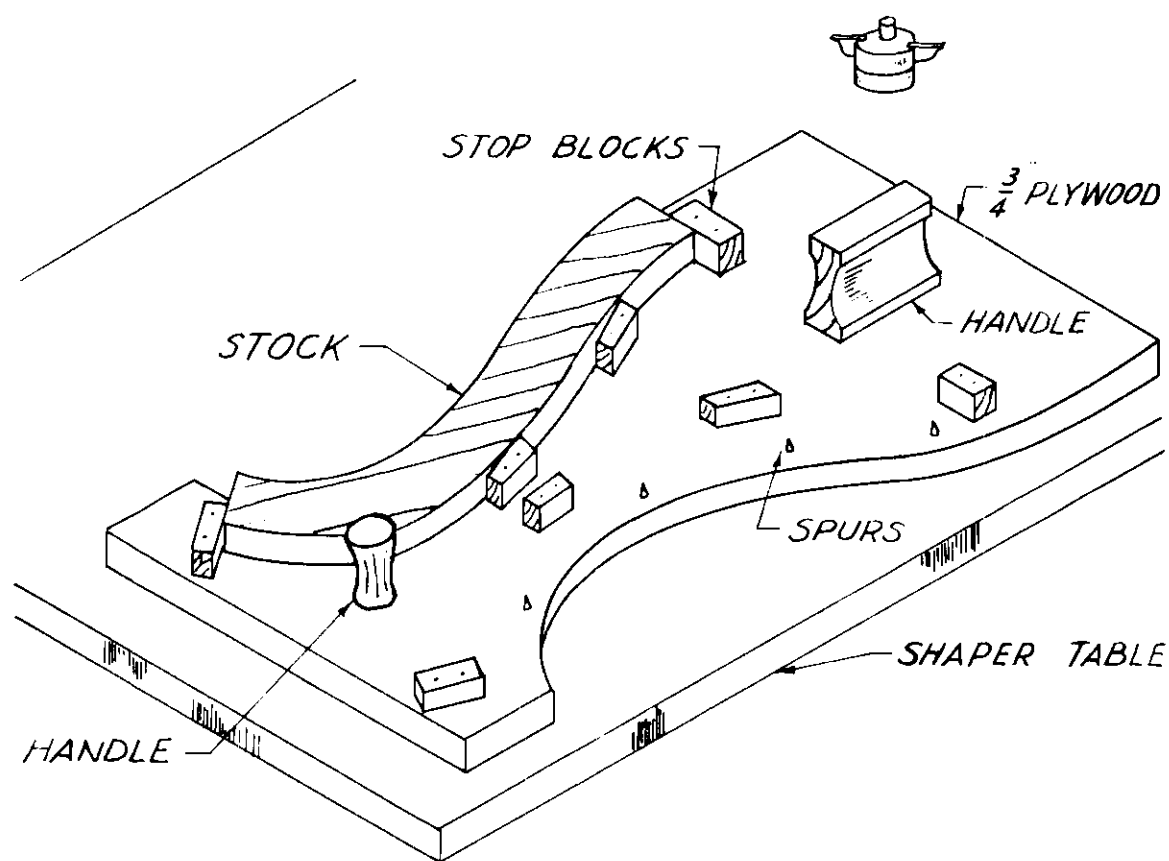
PIVOT
Fig. 38

Fig. 39

Courtesy of Williams Furniture Co.

piece; second, due to the short distance between his hands and the cutter blades.

Figure 39 illustrates a jig used as one method in which a work piece possessing a reverse curved surface can be machined. The tiny spurs serve to hold the stock firmly in position against the stop blocks while the entire assembly edge is passed through the blades by the operator. This type of jig is useful only for relatively light cuts since the method of hold down is not sufficiently positive to permit heavier passes. For this reason, the handles provided might appear somewhat superficial, but they do serve to keep the operator's hands away from the cutters. It is readily seen also that it lends itself to safer activity by virtue of its "double barrel" effect which reduces by one half the total number of loading and unloading cycles of the jig in the vicinity of the moving cutter blades.

Another method of holding stock while the reverse curved edge is machined is shown in Figure 40. A lever with a protruding spur is mounted in such a manner that as pressure is applied toward the stationary handle, a cam action produces a force against the end of the stock, forcing it in turn against another spur which protrudes from a stop block at the other end of the jig. As pressure is applied and increased on the lever, the stock becomes more secure while the shaping cut is being made. Since the base is of the desired shape, the work piece assumes the same outline when the edge of the jig follows the shaper collar. This type of device offers the advantage of quick loading and unloading properties, but it could be improved by the addition of a more suitable handle for the operator's right hand.

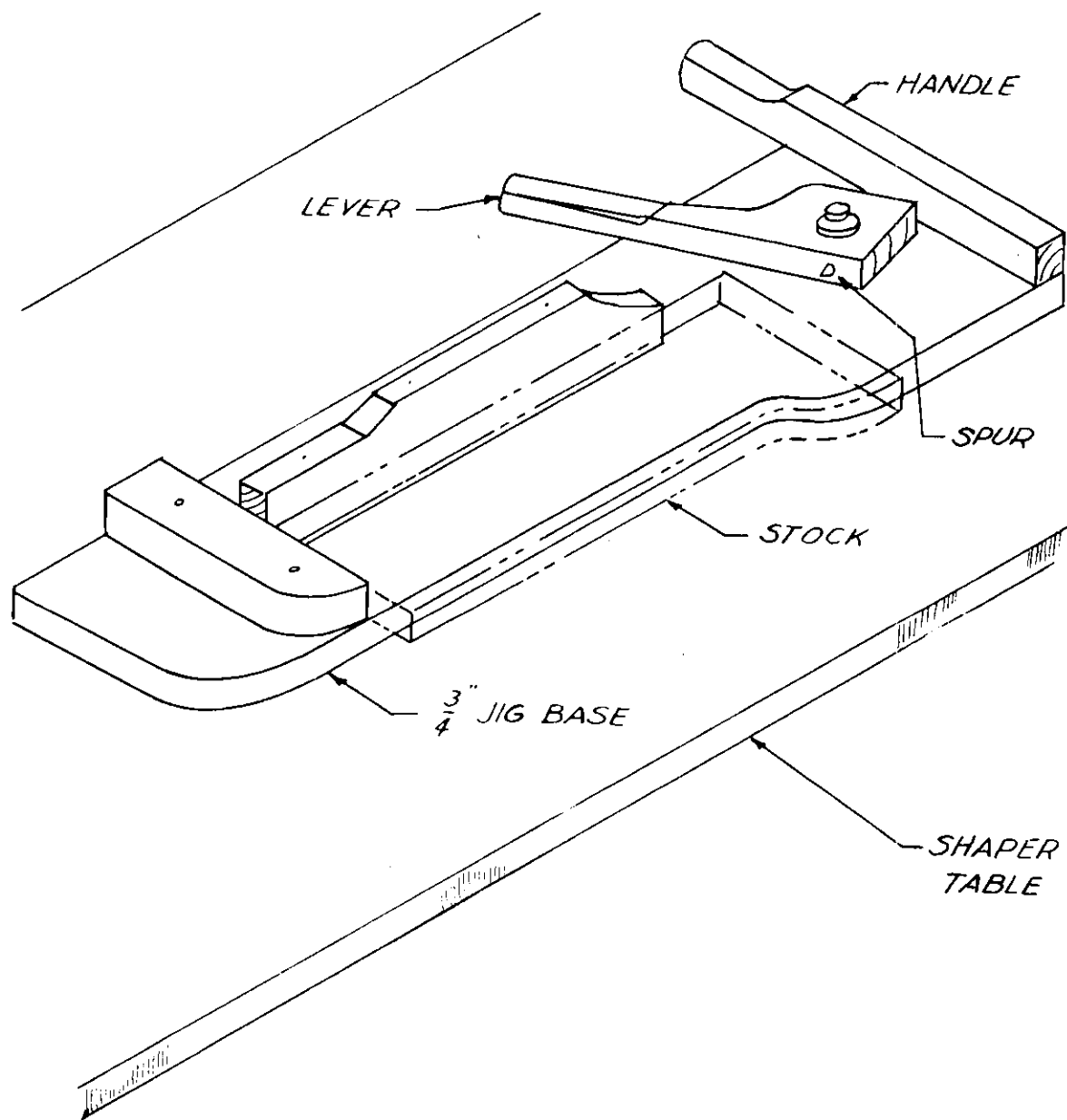


Fig. 40

Courtesy of Williams Furniture Co.

Still another example of reverse curve shaping is illustrated in Figure 41. This type of jig can be used only when the work piece possesses a triangular shape including one square corner before the machining is begun. The right angular fence serves as a stop block on two sides while the holding function is accomplished by means of a screw clamp. A heavy jig of this type permits a deep cut to be made with little chance that the stock will slip out of place during the cut. The extra thick base also offers more contact area on which the shaper collar may bear, thereby allowing a smoother cut to be made.

Often, it is necessary for cuts to be made end-wise in the stock. This operation presents a more hazardous relationship between the operator and the material in that the work piece, as it moves through the cutter, is subjected to a greater strain due to the end grain cutting. As a result of this increased reaction, loss of control of the work is more apt to occur. To meet this problem, a jig shown in Figure 42 is used by one furniture company. The stock is held in place by the fixed fence and a force exerted outward on the two eccentric levers, which in turn serve as handles for the entire assembly. The position of the levers is such that if the proper grip is maintained, the hands can not come in contact with the cutter blades. It is also noted that the holding clamps are rendered more effective by the use of felt or rubber pads on the contacting edges.

The condition discussed above becomes even more prevalent when the stock to be end-machined exceeds one inch in thickness. Obviously, the force exerted on the jig by the machine increases proportionally to the increase in stock thickness. Therefore, to properly meet the

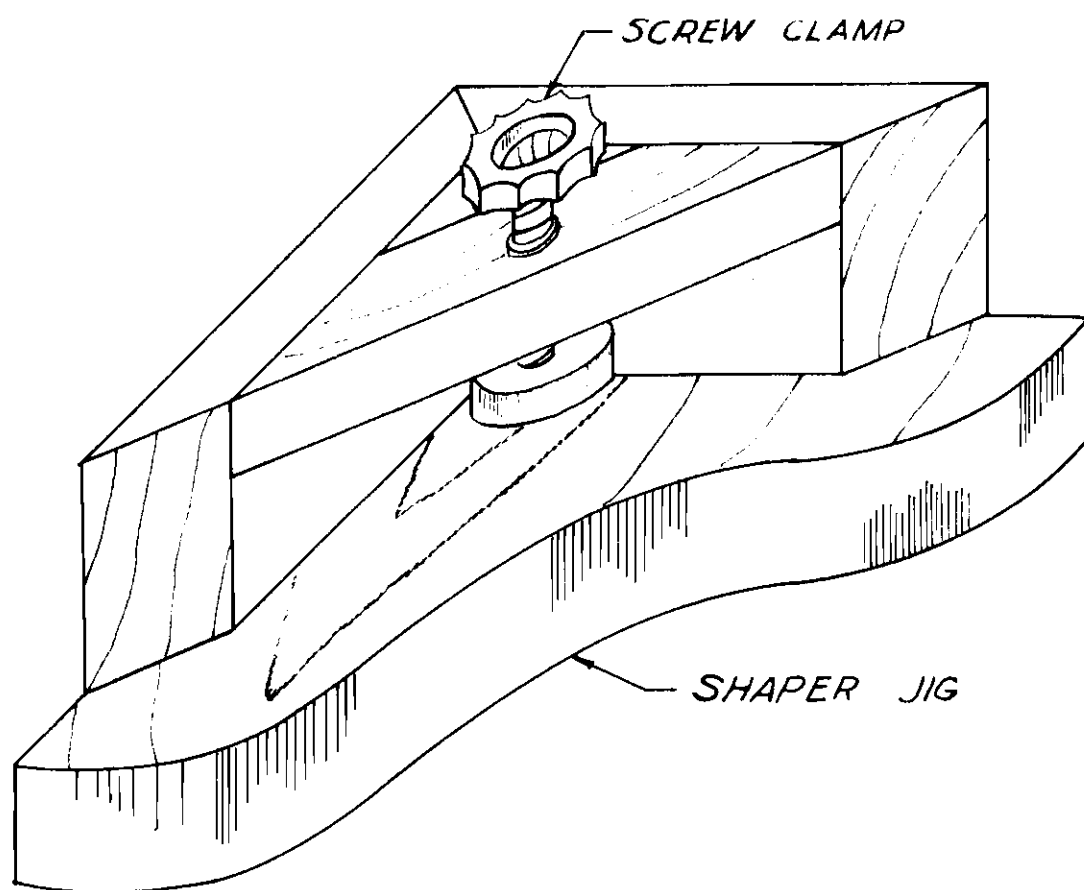


Fig. 41

Courtesy of Baldwin Piano Co.

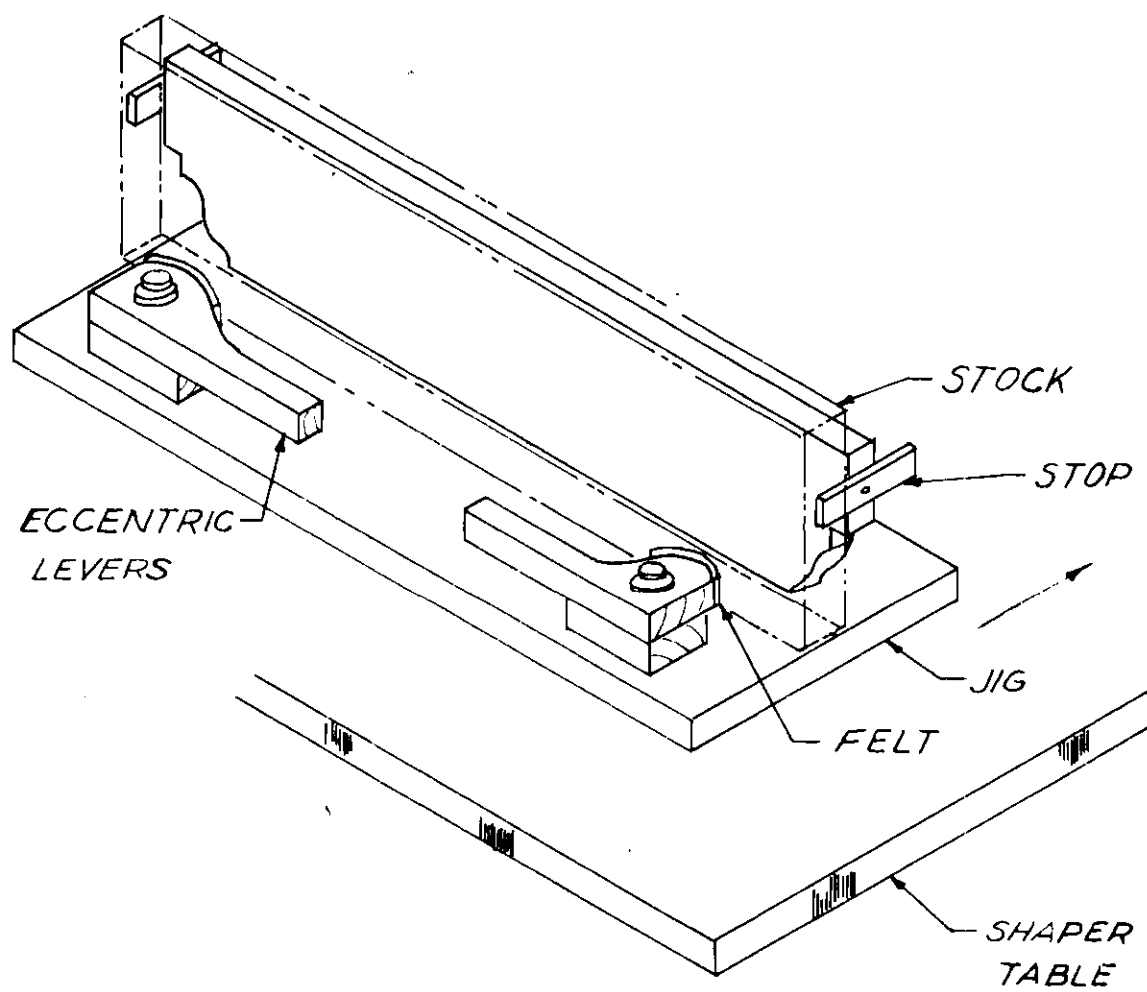


Fig. 42

Courtesy of Williams Furniture Co.

problem, a jig was devised by one manufacturer to hold such heavy stock as is shown in Figure 43. The work piece rests against the stop block at one end; when the end to be cut is pressed against the vertical fence, the eccentric cam-action lever is drawn against the stationary handle. By such a use, both hands of the operator are concentrated on one end of the stock in order that the necessary lateral force may be applied in the direction toward the cutter. This eccentric lever is also trimmed with a felt pad on its stock contact edge, and in addition, a sheet of sandpaper is attached to the fence at the contact point to increase the holding facilities of the jig.

When moldings are to be shaped across the ends, the work is usually done with cutters of the same outline as those with which the molding itself was made. Shown in Figure 44 is an exception with heavy, short pieces of cove molding being machined by straight shaper cutters.

In an operation of this type without a holding device, the stock, due to the nature of the end grain cut being made, tends to be forced from the operator's hands. The short length of the piece also results in a magnification of this effect. To hold the molding and advance it in proper registration, a swing arm (Figure 44) is used. As indicated, its forward edge is notched to receive the work piece. The clamp serves dually as a holding device and to provide handles by which the unit is moved through the cutting stroke. The fixed pivot provides a positive contact between the machine and the material. A stop (not shown) is arranged to limit the forward swing, thereby preventing the swinging arm from receiving inadvertent cuts. By using this method, the hazards of operator-machine contact are minimized and those of operator-material relationship are eliminated.

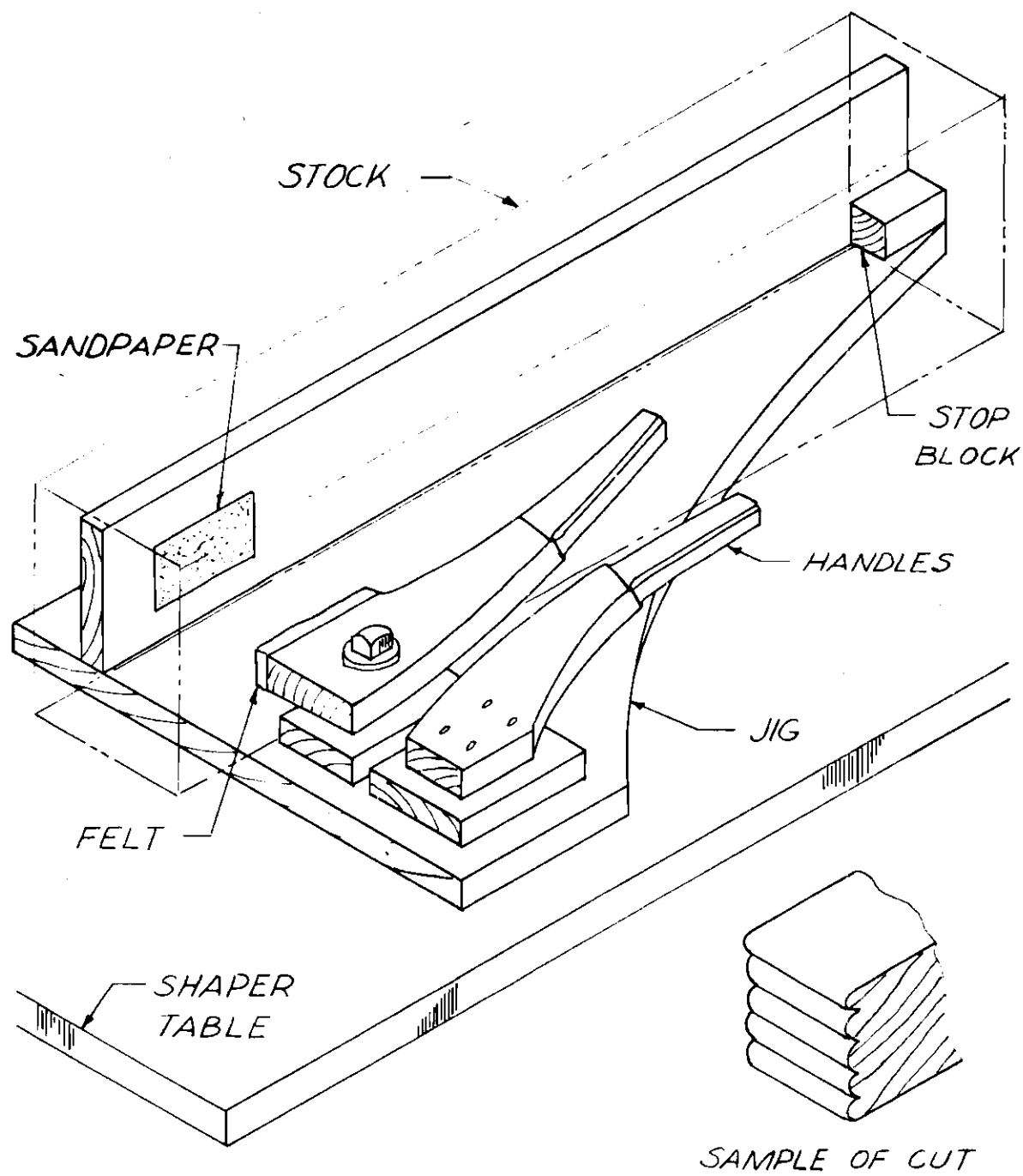


Fig. 43

Courtesy of Williams Furniture Co.

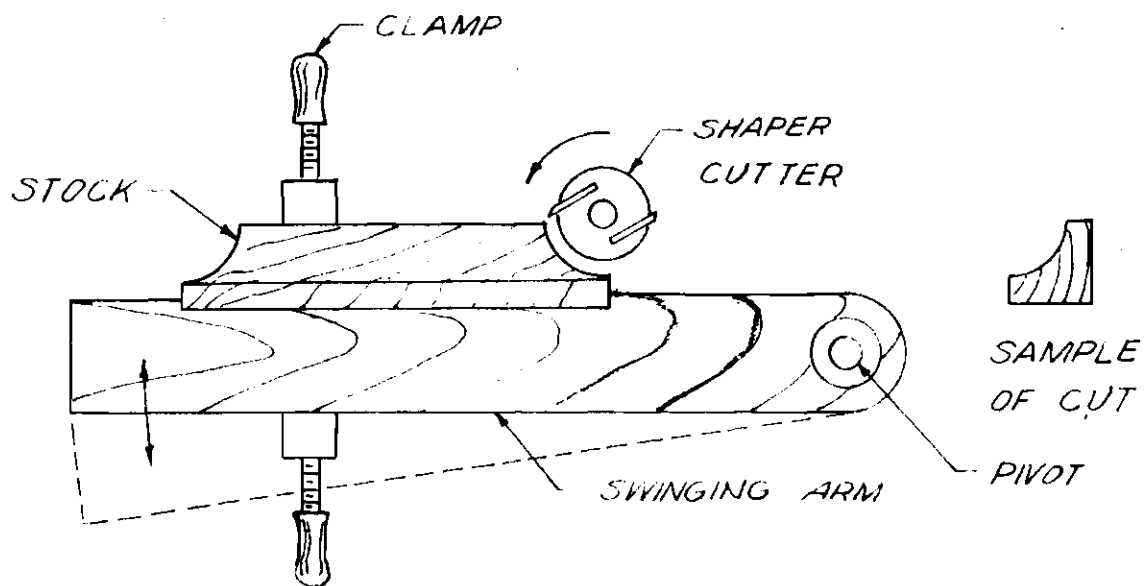


Fig. 44

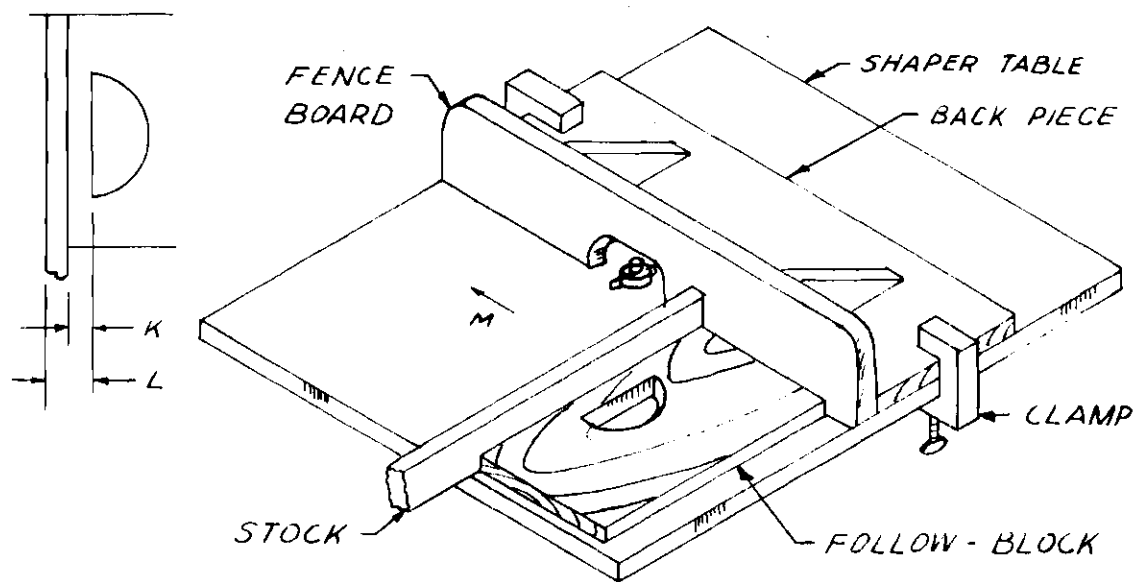


Fig. 45

Courtesy of Baldwin Piano Co.

In the woodworking industry there is used a device known as a follow block. This is a small block of hard wood placed behind a work piece that is being knife-machined across the grain. The purpose of this block is primarily to prevent the knives from tearing the grain as they emerge from the end of such a cut.

Figure 45 shows a special follow block application at the shaper in which the block is far larger in size than the work piece itself. Due to the narrow width of the stock and because it must be processed past a gap in the fence, the type of wide block shown is used.

The problem is to pass pieces of stock across the cutters without allowing them to slip into the gap in the fence, or to move out of right angular relationship with the face of the shaper fence while the cut is in progress. The follow block is designed for this purpose.

In order to provide for holding the stock firmly against the follow block, the latter has a semi-circular opening cut through its forward portion, leaving a sufficient amount of material in the span K. When the narrow width of the stock is combined with span K, distance L is the resulting span which allows the stock and the follow block to be held firmly together with the finger of the operator's left hand, while the right hand is used to move the follow block forward in the direction indicated by arrow M. In this manner, the stock is properly and safely supported as it travels past the gap in the shaper fence.

It is noted also that where quite heavy cuts are involved across the ends of such stock as is shown, the work piece can not be held tightly enough to the follow block with the fingers to insure that it will not slip under the thrust of the cutters. This can be readily accomplished by using a small hand screw clamp across span L.

To cut a spline or a slip tongue, as it is sometimes referred to, a hand-feed shaper is used with a saw-type cutter mounted on the spindle. In Figure 46 is shown a method using a form for holding the stock at a 45° angle while a slot is cut in the edges which have also been beveled to a 45° angle. This arrangement places the particular beveled face in a vertical plane and at the same time, provides a positive guide on which the stock rests during the entire cutting cycle. The operator is thereby relieved of any necessity of directing his attention to the proper angle of the stock piece while exerting downward and horizontal forces on the work.

Due to the tangential force present at the periphery of the saw type cutter, the operator's forward motion is met and reacted to in the horizontal plane. However, his downward motions are received only by the jig which is clamped to the table. To further maintain the work piece in its proper position, a small slot is cut into the inclined rest to receive a thin bearing strip of planed hardwood. As the sharp edge of the stock rides against the strip, practically no danger to the operator can result from stock slippage.

Although several types of shaper jigs have been discussed in which the basic principle involved is that of holding the stock securely, mention is made at this point of still another variation of this category.

In many cases it is necessary to machine stock, the size of which is of greater proportions than that already mentioned. Figure 47 illustrates a jig which is designed to hold a piece of stock ranging up to two inches in thickness while a concave curve is machined into its edge.

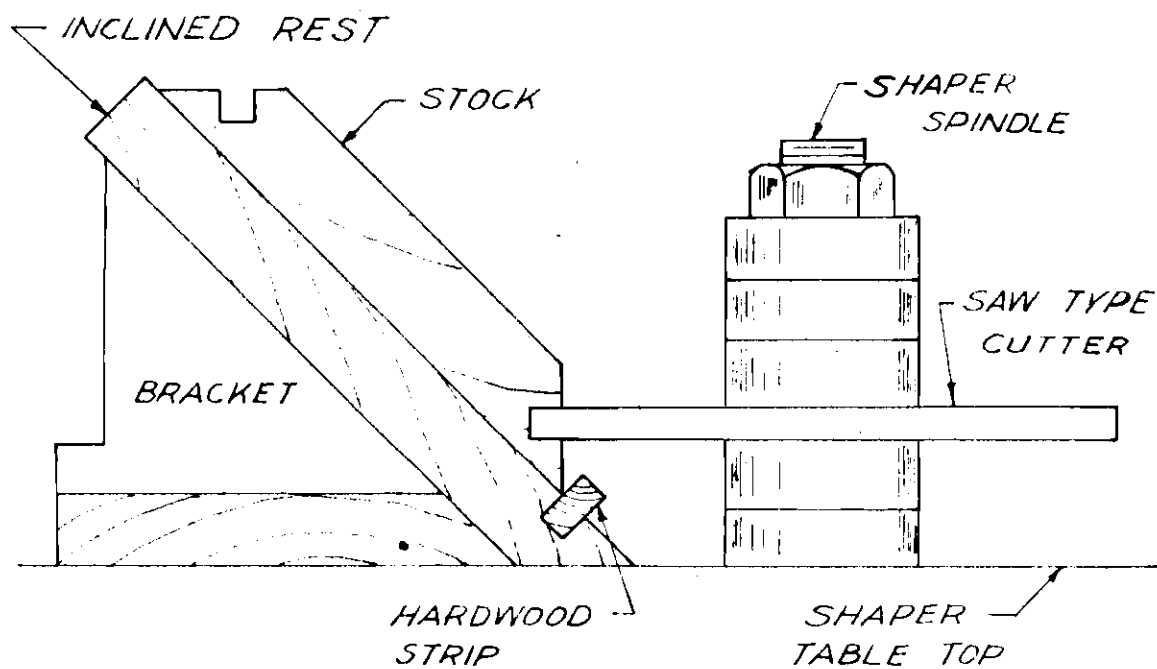


Fig. 46

*Courtesy of The Woodworker
Magazine, 67: 26 Dec. 49*

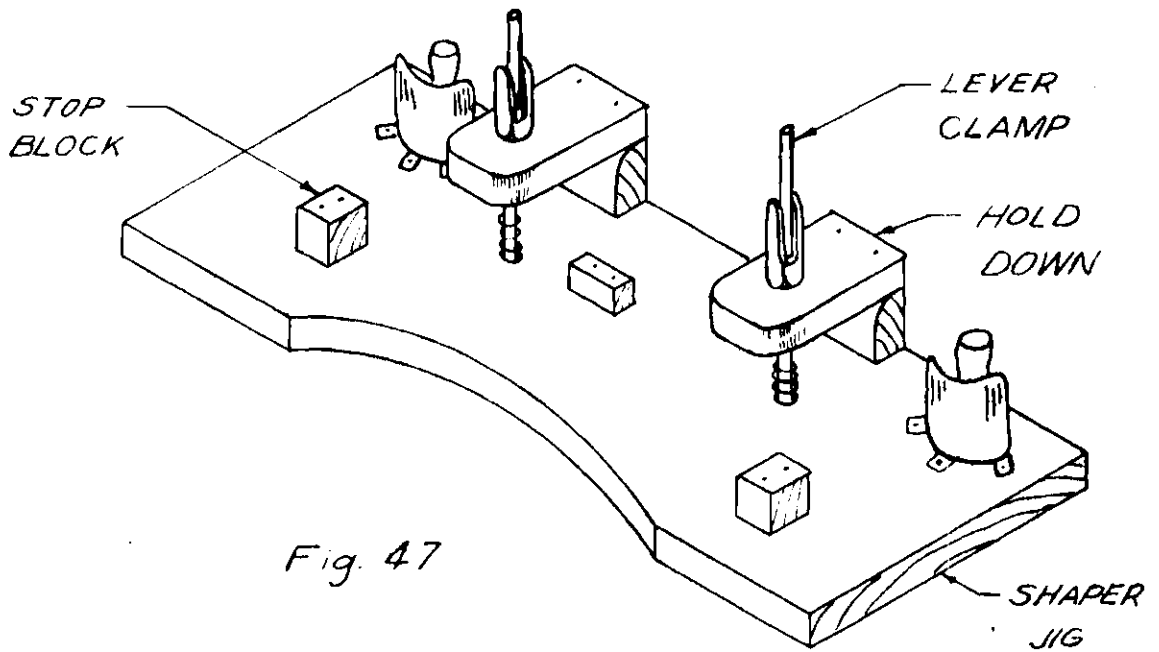


Fig. 47

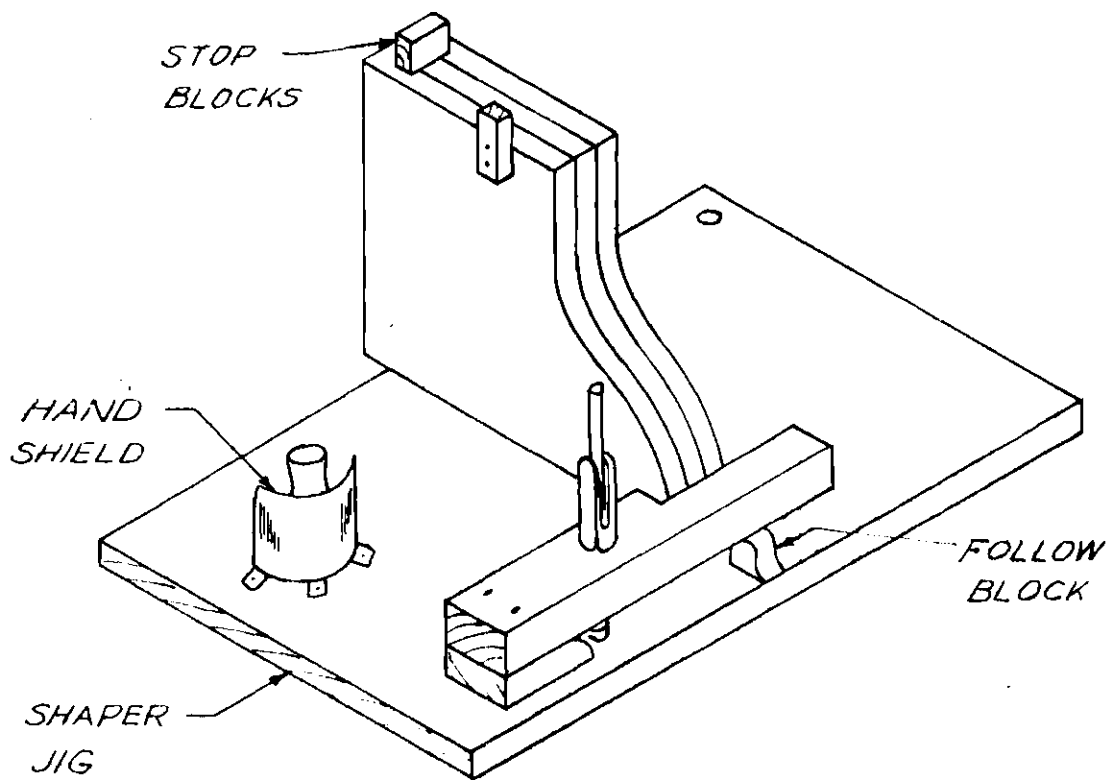


Fig. 48

Courtesy of The Mengel Co.

In addition to the stop blocks shown, the stock is securely held in place by a pair of quick-action lever clamps. These clamps were designed and built by one of the furniture manufacturing companies visited by the writer, and are illustrated in more detail in Figure 49. It is noted that the clamps act on the hold down arms which are in turn spring loaded to open quickly when the clamp is released. This measure permits fast, positive loading and unloading.

Another unique feature of this jig is its metal shielded handles which prevent the operator's hands from contacting the cutters should he happen to slip during a forceful movement. This company reports that a great reduction in its accident frequency rate is attributed to the use of these shields on all jigs of this type.

In Figure 48 is shown a variation of the same arrangement. This jig holds a Duncan Phyfe table leg while the toe is machined. The same features are utilized as in the preceding example except in this case, the cut is made across the grain while the work piece is held safely and conveniently in place. A follow block, the principles of which have already been discussed, embraces the lower end of the work piece to further strengthen its position during the rigorous cross-grain cut.

Heavy duty shaping work is necessary on large pieces such as those used in some phases of piano construction. A jig similar to that shown in Figure 50 is most serviceable for this purpose and at the same time, quite necessary. Due to the increased amount of thrust which results from machining heavier stock, the amount of force necessary to hold this stock is greater than that produced by the methods discussed thus far. To accomplish this purpose, a jig was devised using the

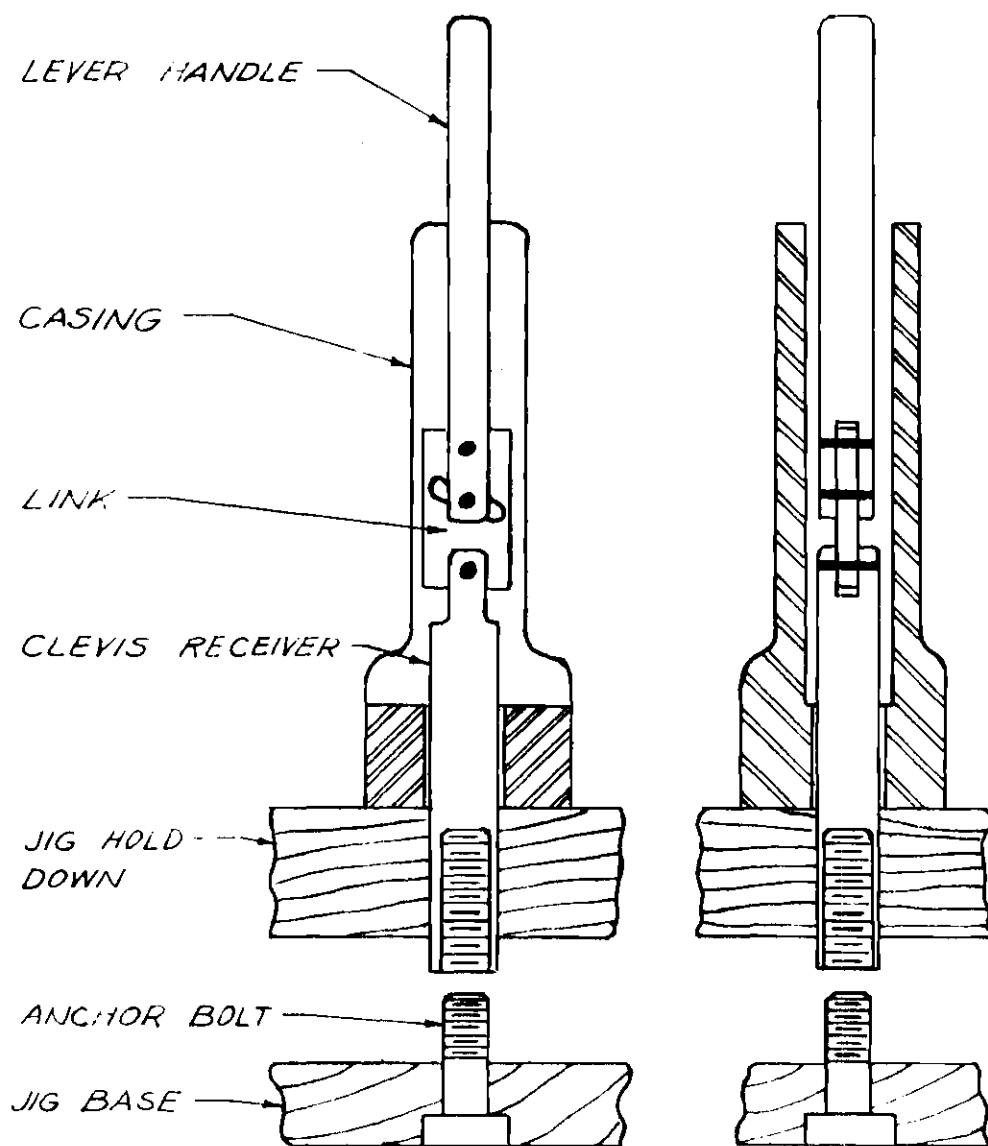


Fig. 49

Courtesy of The Mengel Co.

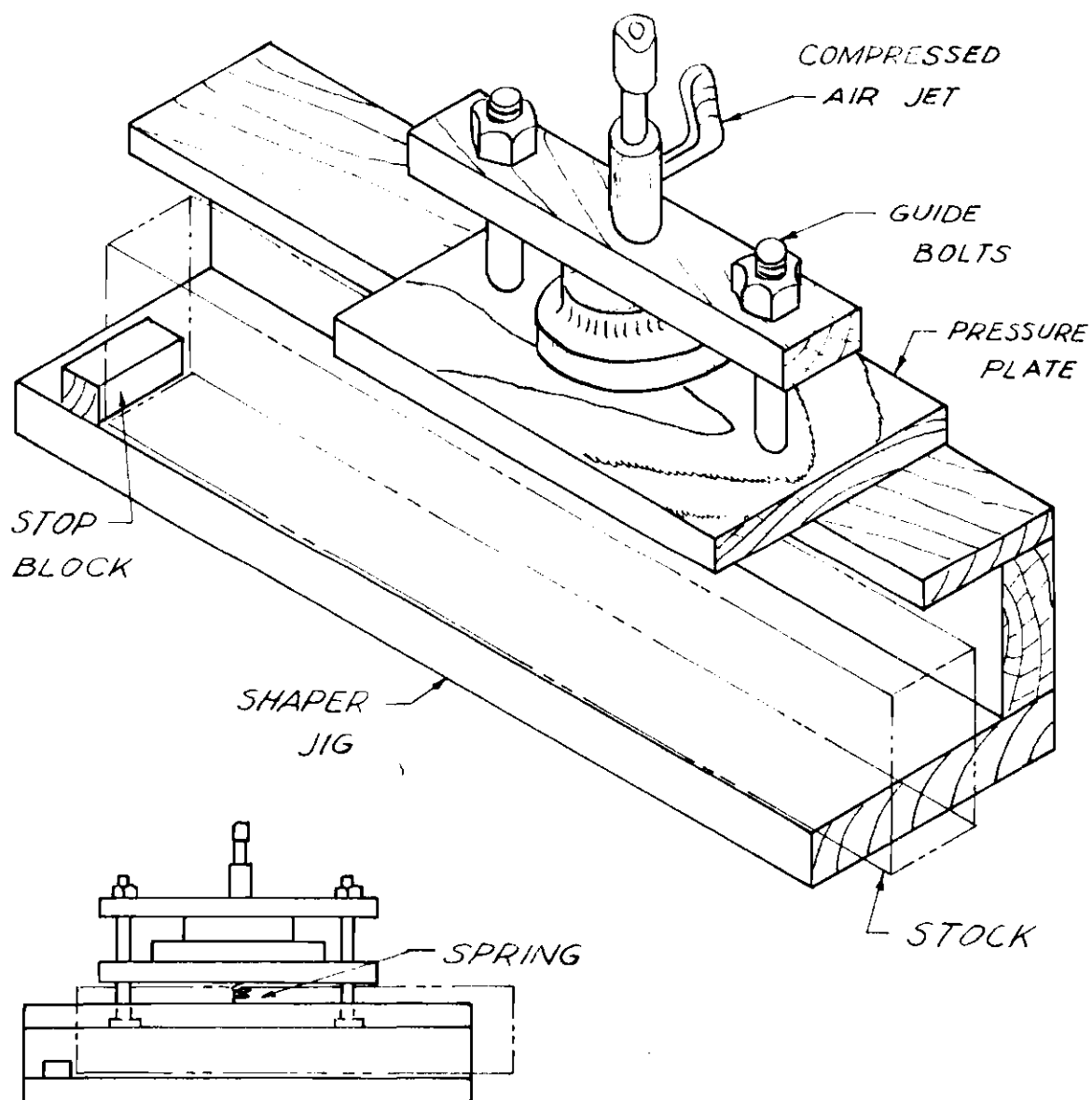


Fig. 50

Courtesy of The Baldwin Piano Co.

principle of compressed air for clamping purposes. The necessary amount of air is admitted by a jet valve to a cylinder attached to a pressure plate. This plate rides on two vertical guide bolts until it contacts the stock, after which more air pressure is admitted, seating the pressure plate firmly on the stock piece. Although the process is dependent on a steady supply of compressed air, it is quick acting, lending itself effectively to high production through rapid loading and unloading.

It is pointed out, however, that there is still opportunity for improvement on this jig inasmuch as no actual handles are provided for the operator to grasp. In its existing condition, with the guide bolts being used as handles, injury to the operator is quite possible if, for example, the hands should accidentally release the air pressure during the cutting operation. In this event, the material-operator relationship would present some hazard due to possible contact between loose stock pieces and the rotating cutter blades.

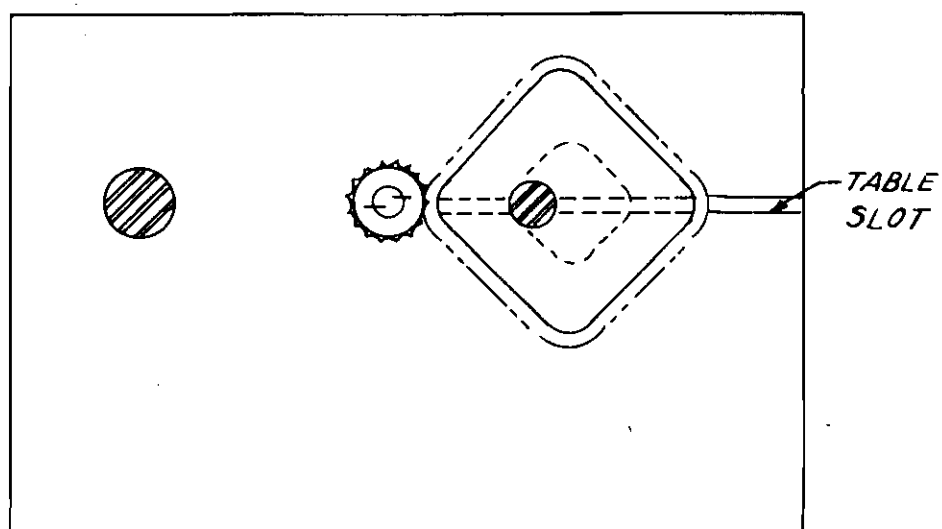
If the method of shaping about to be discussed could be applied to all types of equipment, the furniture manufacturing industry would have practically no "point of operation" accidents on such machines.

Reference is made to the automatic shaper. This is a very high production type of machine in which the stock is clamped to the table by means of compressed air and automatically fed to the knives. Work is done on this machine "after a pattern", a method by which the stock is held in position either with steel points or with clamps. The pattern is forced against the spindle with compressed air as it is rotated by a variable speed motor, and both pattern and stock are held firmly to the table by a vertical air clamp.

One manufacturer uses a sprocket and chain drive similar to that shown in Figure 51. The sprocket fits over a spindle and is driven independently at a much slower speed than that of the machine cutters. The chain is fitted around the pattern and engages the teeth of the sprocket wheel. An air-operated pressure roller mounted on a slide in the table, engages the underside of the pattern and forces it against the spindle; this action keeps the sprocket wheel and chain always in mesh.

Due to the properties of this machine which make it almost completely automatic, the operator is relieved of the hazardous exposures found in the machines and operations discussed thus far. Therefore, his only function on this machine is to load and unload the work pieces at some distance from the point of operation.

Another manufacturer uses a circular revolving table with radial slots to which the pattern is clamped. The stock is held down on the pattern with air clamps and is forced against an overhead cutter as the table is revolved by a variable speed motor. On this machine, the pattern or form can be made to cut several pieces of the same shape at one revolution of the table. As the finished pieces pass in front of the operator, the air clamp releases them, permitting new pieces of stock to be inserted by the operator. Once the machine is set up, the procedure of tending it is simple and relatively safe.



SECTION A-A

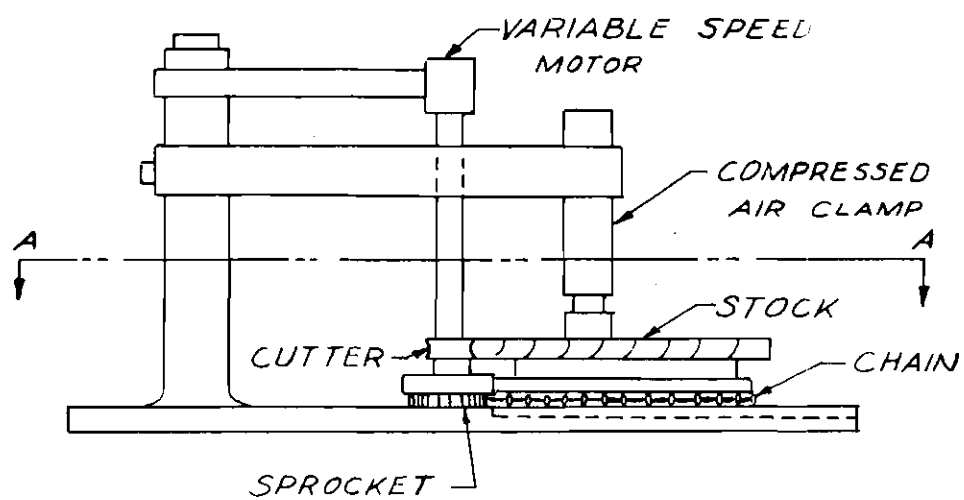


Fig. 51

Courtesy of The Mengel Co.

THE ROUTER

Basically, routing and shaping are quite similar, differing chiefly in their speed of rotation and diameter of cutters. The main difference is that the router mounts a cutter spindle above the table to cut from the top of the work, while the shaper has its spindle below the table to cut primarily on the edge of the work.

Since the feeding principle of the router consists of the stock being guided by a pin-in-the-table arrangement, there is little chance that lack of control of the work piece or jig will result. Consequently, the hazards to the operator are appreciably reduced.

Work that can be done with small diameter cutters and light cuts such as slotting, interior work, grooving, and line work is usually done best at the router. This type of operation is accomplished with a straight bit which has a molding cutter at its upper end near the shank. When used for carving or scrolling work, a jig similar to one of those shown in Figure 52 is slotted on its under side to correspond with the contour of the required design; then the slot is positioned over the guide pin which is directly under the revolving cutter bit. An infinite variety of molding and shaping cutters are easily and quickly mounted on the spindle, which is operated at speeds ranging upwards to 20,000 r.p.m. As long as the eccentric lever clamp holds the stock in place against the guide blocks, and the slotted form follows the guide pin, there is little danger to the operator.

It is seen that the two jigs in Figure 52 are quite similar, differing only in the method of guiding the clamping member in a direction parallel to the backward and forward motion of the operator's

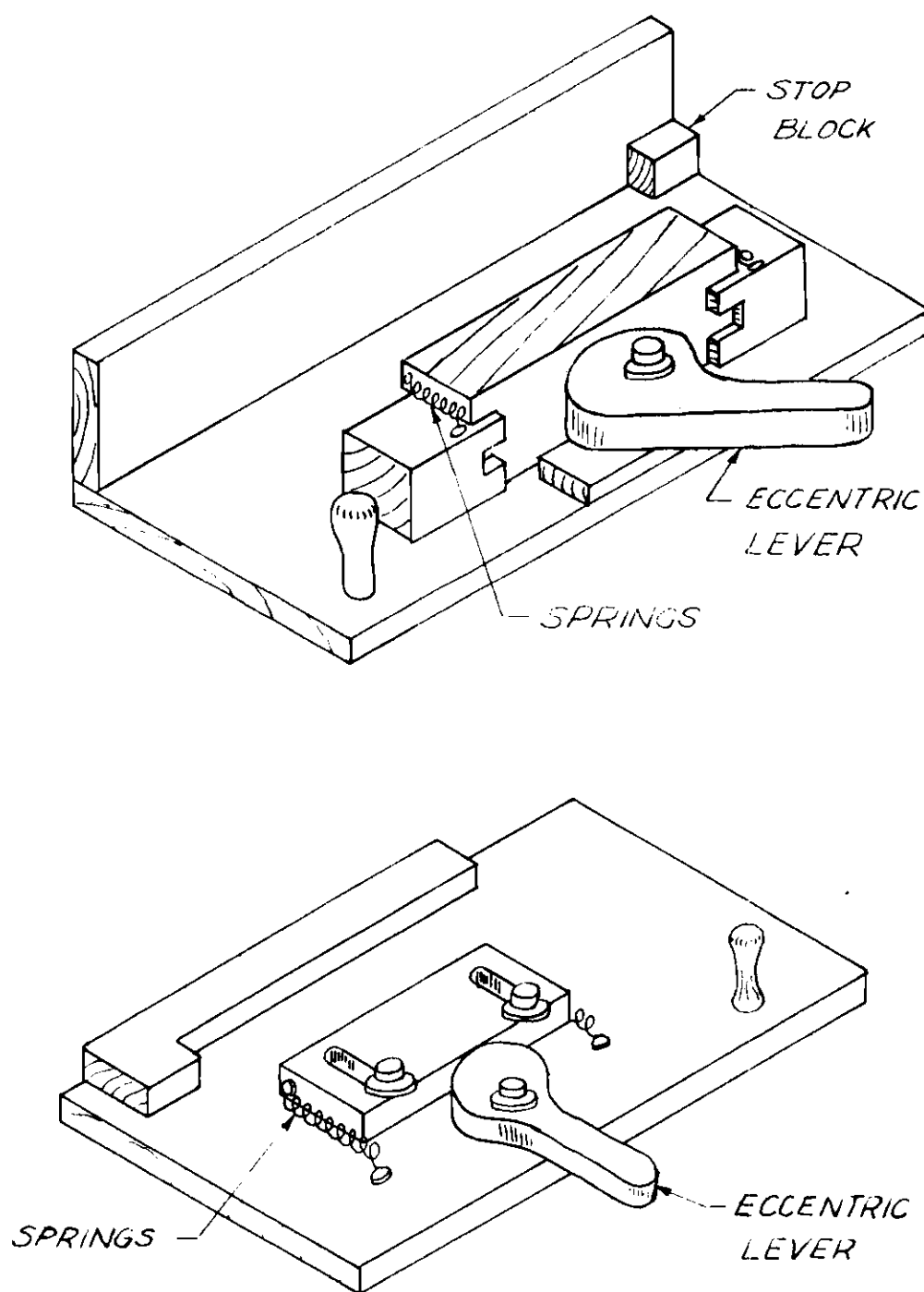


Fig. 52

Courtesy of The Mengel Co.

hands. The stop-blocks serve to further assure that the work will remain in position during transverse movements.

Another router cut is performed on the elbow type machine. In this as well as in various other operations, the cutter is moved while the stock remains stationary. Figure 53 shows one example of this procedure. The stock to be machined is clamped against the formica guides while the cutter bit is moved backward and forward through the pre-cut grooves of the jig; the cutter being guided through its path by an overhead follow-rail. In addition to the work being held safely by the vise-like screw clamp, the jig is capable of even higher production operation with the addition of a similar clamp (not shown) on the back side of the jig fence.

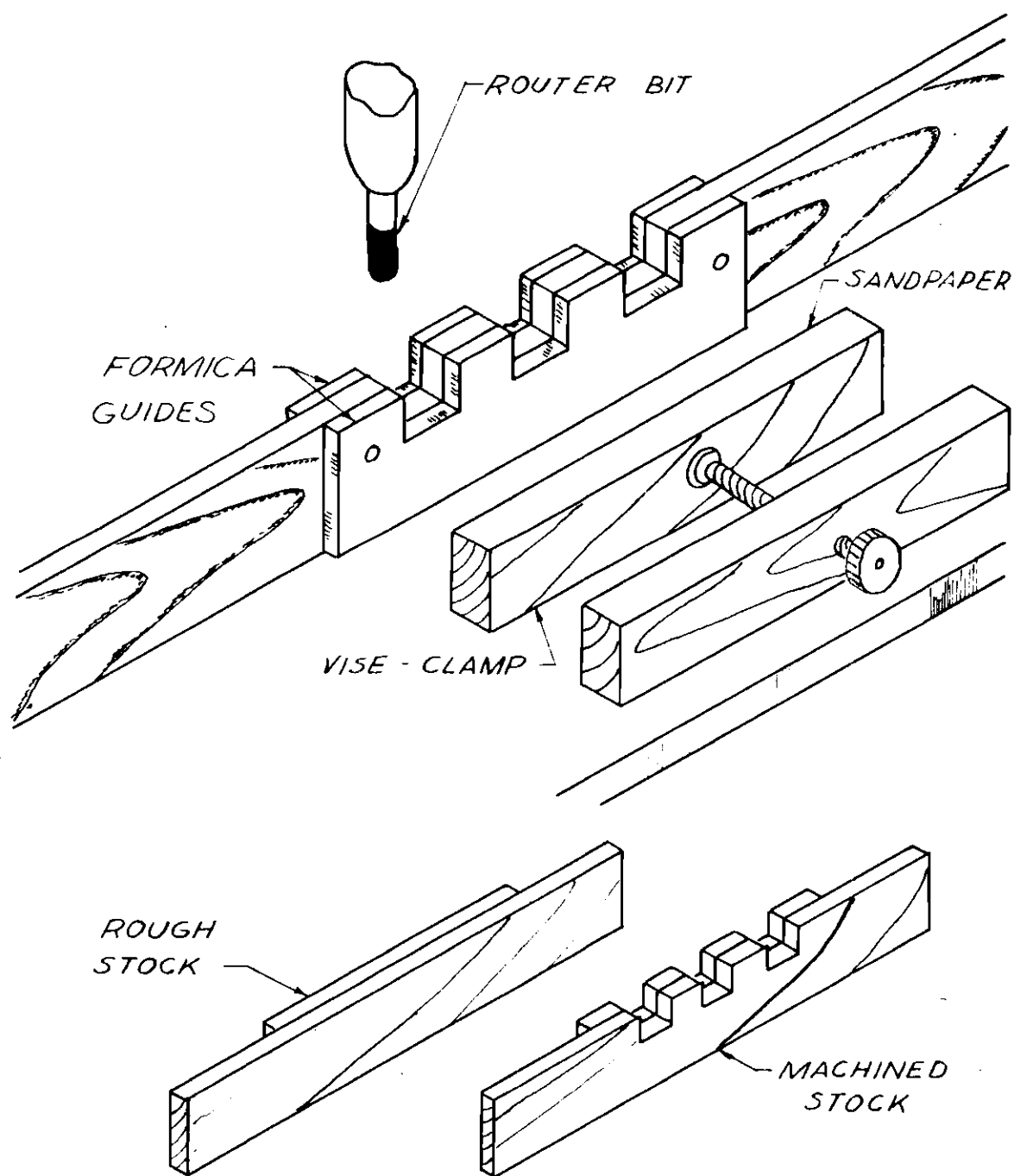


Fig. 53

Courtesy of Baldwin Piano Co.

THE DRILLING MACHINE

Harmless as it may appear, the drilling machine also presents some safety problems. Drilling or boring consists of two different basic conditions; that of stationary stock being met by the movable tool, and the mobile stock engaging the fixed drill.

When the need arises for holes to be drilled in lathe-turned surfaces such as table legs, bed posts, and piano legs, the problem of keeping the round surface from rolling is presented. Shown in Figure 54 is a jig used for such an operation. The leg stock is received by the hollowed-out holders in matching concave surfaces. A clamping member possessing similar curved surfaces is tightened from the top in order to secure the stock ready for safe drilling.

The procedure of drilling dowel holes can become troublesome, especially when the holes to be drilled are in a plane oblique to the surfaces of the stock. A solution to this problem is illustrated in Figure 55. It consists of a specially constructed jig with stop blocks placed at the desired angle in which the stock is to be held. Since the work pieces are embraced on three sides by the jig, no additional clamps are necessary other than the operator's hands. To further secure the device, the entire assembly is clamped to the drill table. In addition to drilling safely, this type of jig offers a highly productive operation due to its left and right side loading opportunities.

End drilling is another type of dowel hole operation necessary in furniture manufacturing. This procedure requires more force to be exerted on the stock during the cut due to the end grain cutting, and to the usually small cross-sectional area of the working surface.

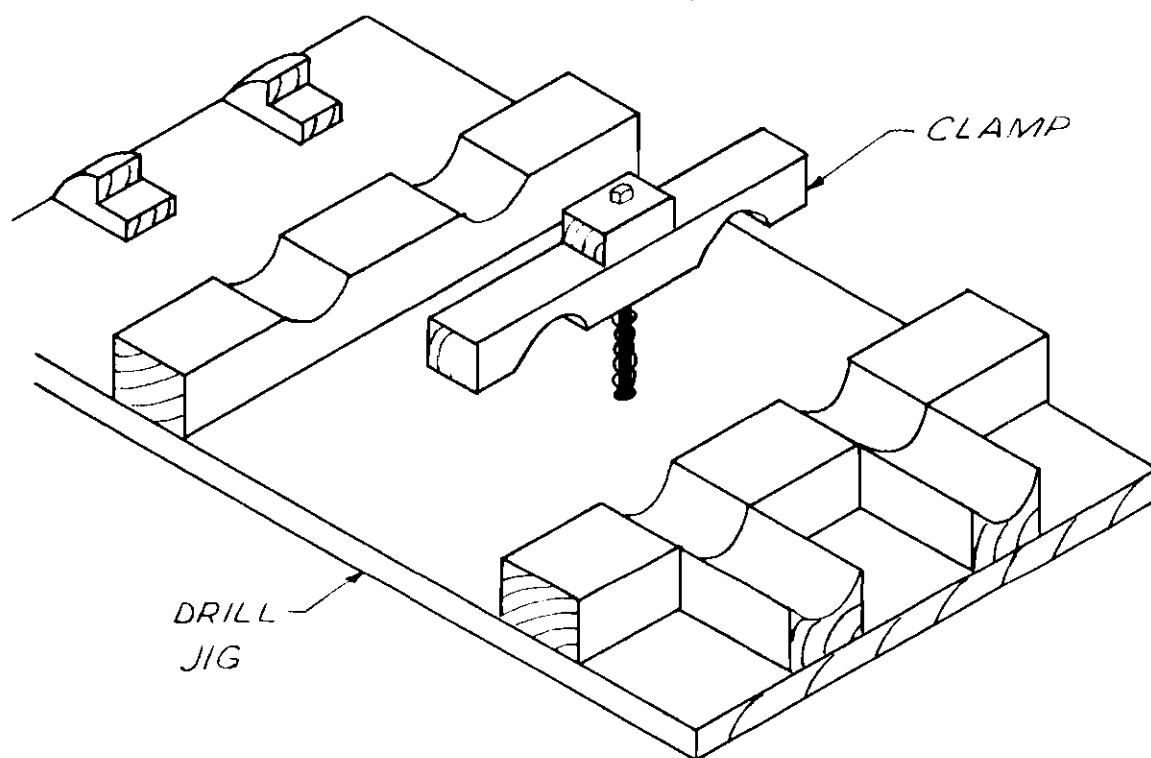


Fig. 54

Courtesy of Baldwin Piano Co.

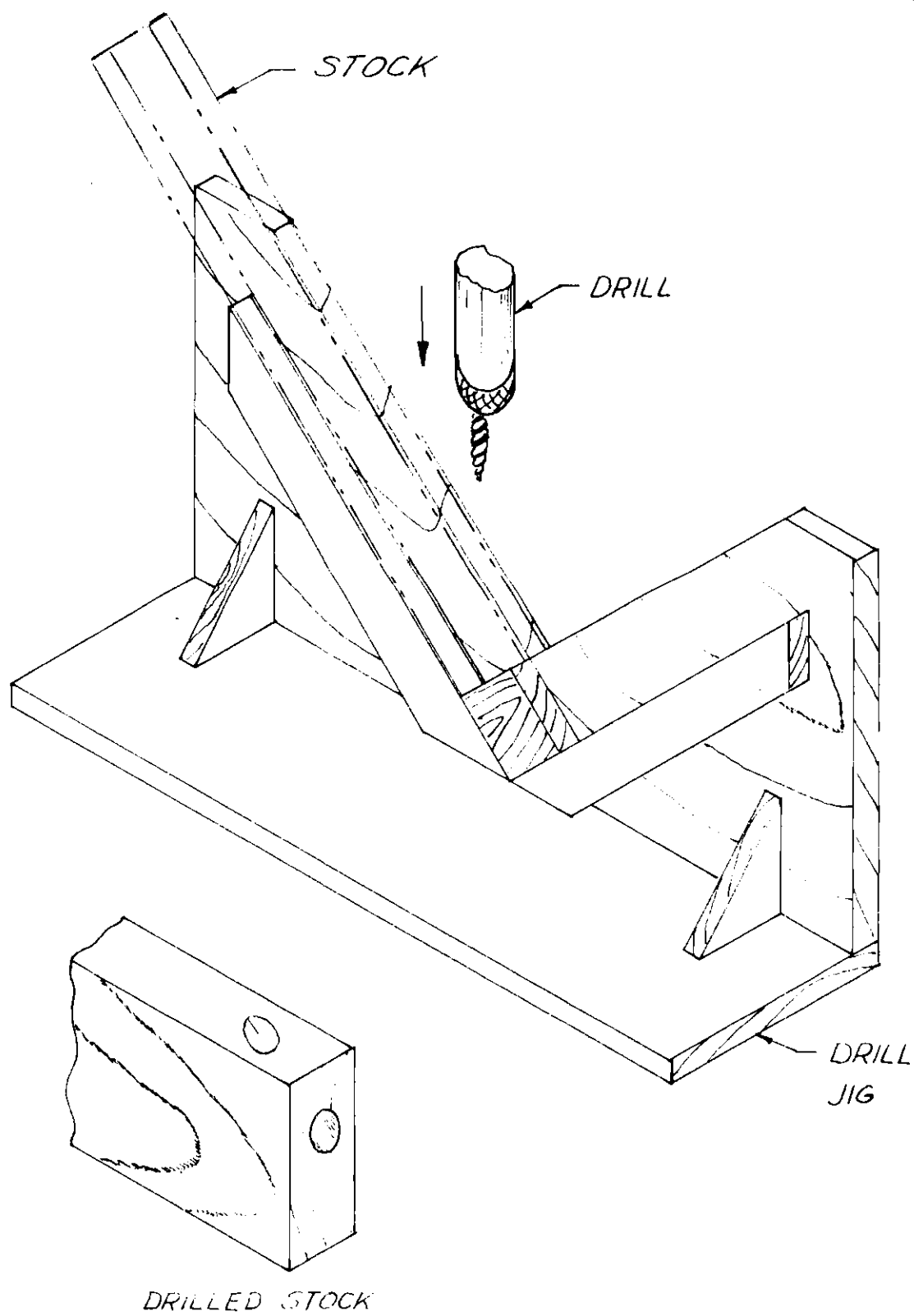


Fig. 55

Courtesy of Baldwin Piano Co.

In Figure 56 is shown a direct-connected single spindle drilling machine of the horizontal type; the stock being held rigidly in position with an air powered hold-down. The spindle moves to and from the work table and can be quickly adjusted for length of stroke. As the bit advances to the cut, the clamp closes automatically, holding the stock firmly; then air pressure is released on the return movement. After allowing sufficient time for the operator to re-load, the bit again advances and the cycle is repeated.

Lengthwise and crosswise slots in the table provide for simple adjustment of the back fence to which the hold-downs are attached, and for the placing of stops for use in positioning parts to be drilled.

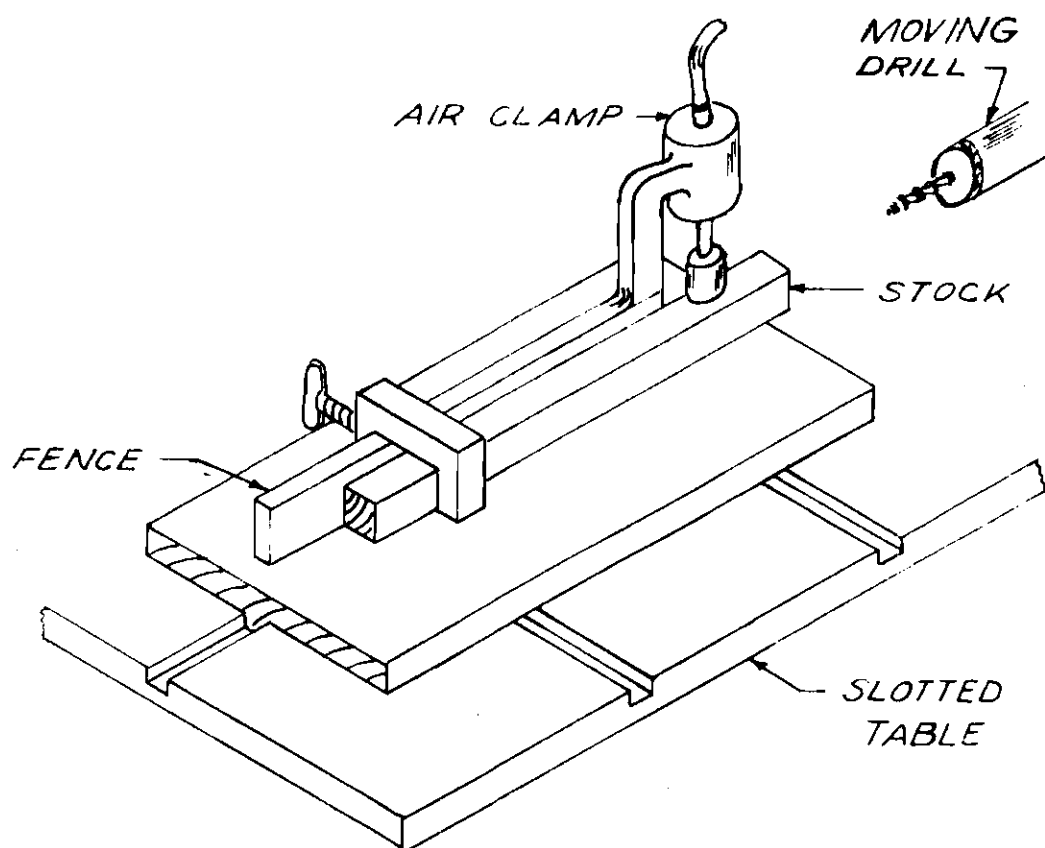


Fig. 56

Courtesy of *The Woodworker Magazine* 68: 69 May 50

THE BELT SANDER

The woodworking machine that presents fewer hazards than any discussed in this project is the belt sander. Obviously, there are no cutting blades present but the finishing operations performed on this machine do present certain hazards.

Since the sanding belt is the moving agency, the jigs used on this machine are either stationary or their motion is limited to a backward and forward movement transverse to the direction of the belt.

One exception to this practice is illustrated in Figure 57. This jig is used to sand edges of pieces possessing reverse curves by fastening the stock in a saddle device as shown. The clamping arrangement is similar to that used on shaper jigs (see Figure 49). As the loaded saddle is rocked on the runners of the jig under the moving belt, the rounded stock makes contact for proper abrasive action. This method of sanding not only produces more accurately finished work at a high production rate, but also removes the possibility of the stock being thrown from the operator's hands. It is necessary, however, that the saddle assembly be held firmly to assure safe and effective use of the jig.

Multiple edge sanding would be a difficult and precarious operation without the use of some type of holding device. The natural tendency in this case is for the motion of the sanding belt to force the stock from an "on edge" position to a flat position.

To meet this problem, one company uses the jig shown in Figure 58. The pieces to be edge sanded are fitted into a series of fences spaced equal to the stock thickness. The pre-cut ends are forced into a notched stop block by the motion of the belt as the abrasive side is pressed

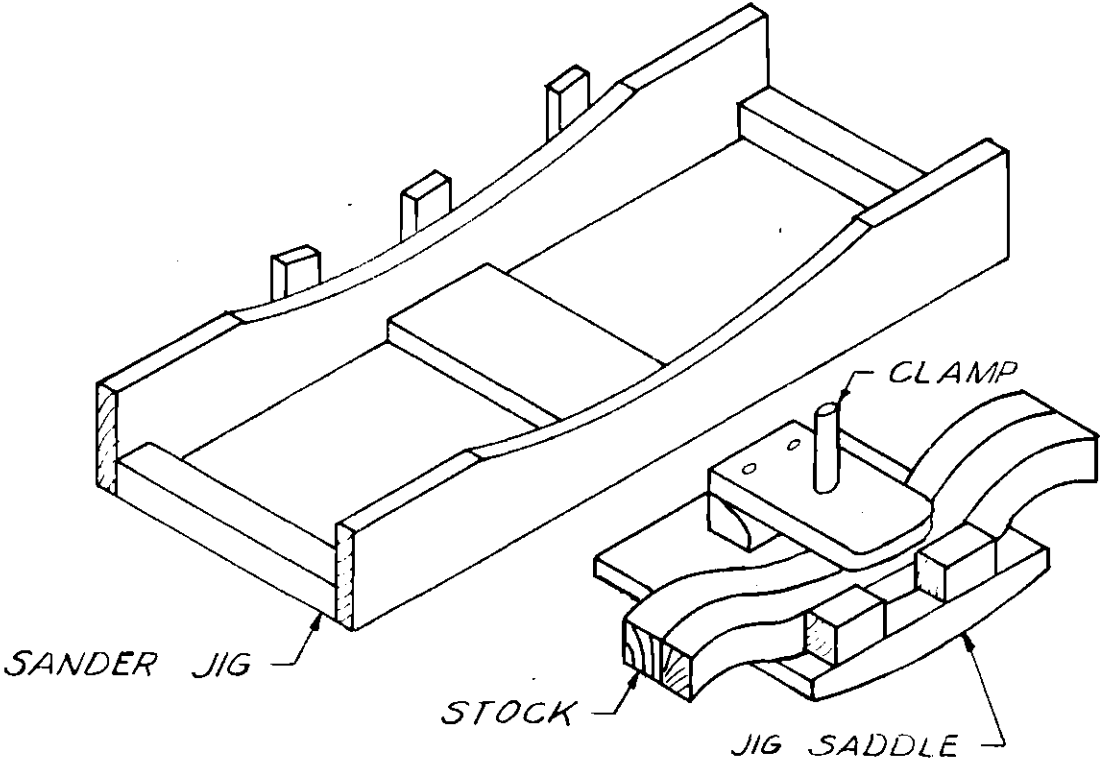


Fig. 57

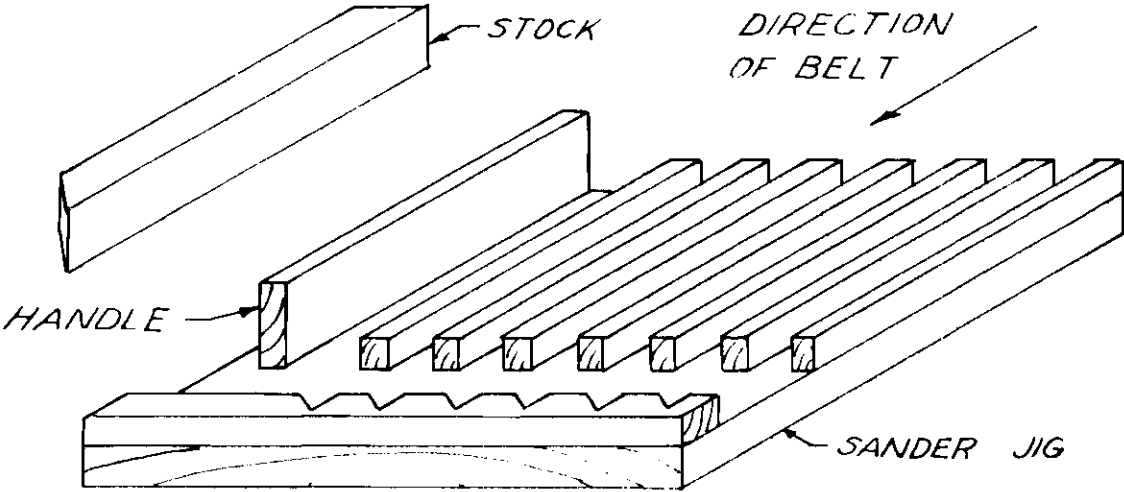


Fig. 58

Courtesy of The Mengel Co.

into downward contact with the edges. By using this method, several pieces are readily sanded to uniform size with little danger of their being thrown out of position or causing injury to the operator. A special handle for grasping the jig is also provided, which saves the operator's hands from knuckle burns, but only so long as the jig is not pushed too far under the sanding belt.

When the sanding operation is applied to curved surfaces of larger radius, the problem of holding the material grows in magnitude as the size of the stock increases. This is due to the unwieldiness of the work piece and the large amount of force exerted on it by the fast moving sander belt. In order to reduce the amount of exposure presented by such operation, a special rocking jig is made available (Figure 59). A framework to fit the contour of the work piece is pivoted on two supports which, in turn, are mounted on a sturdy base. The stock rides the curved surfaces of the frame and is held in position by stop blocks on three sides with the aid of the frictional action of the sander belt. After the jig is in place under the belt, a slight rocking motion about the pivots serves to engage all segments of the curved surface with the belt. The chief concern of the operator then is to see that the jig is fixed firmly to the sander table with "C" clamps to prevent mishap.

In finishing convex edges of smaller radius on the belt sander, it is usually difficult to support the work piece in a plane perpendicular to the axis of the belt pulley unless a suitable fence can be arranged against which the side of the stock can be held and guided.

The method shown in Figure 60 provides smooth, accurate, and safe sanding because the abrasive belt makes contact with a large portion

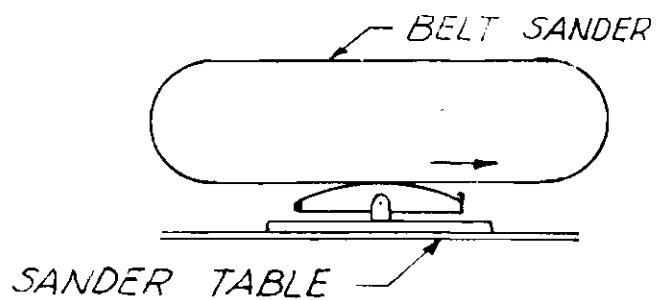
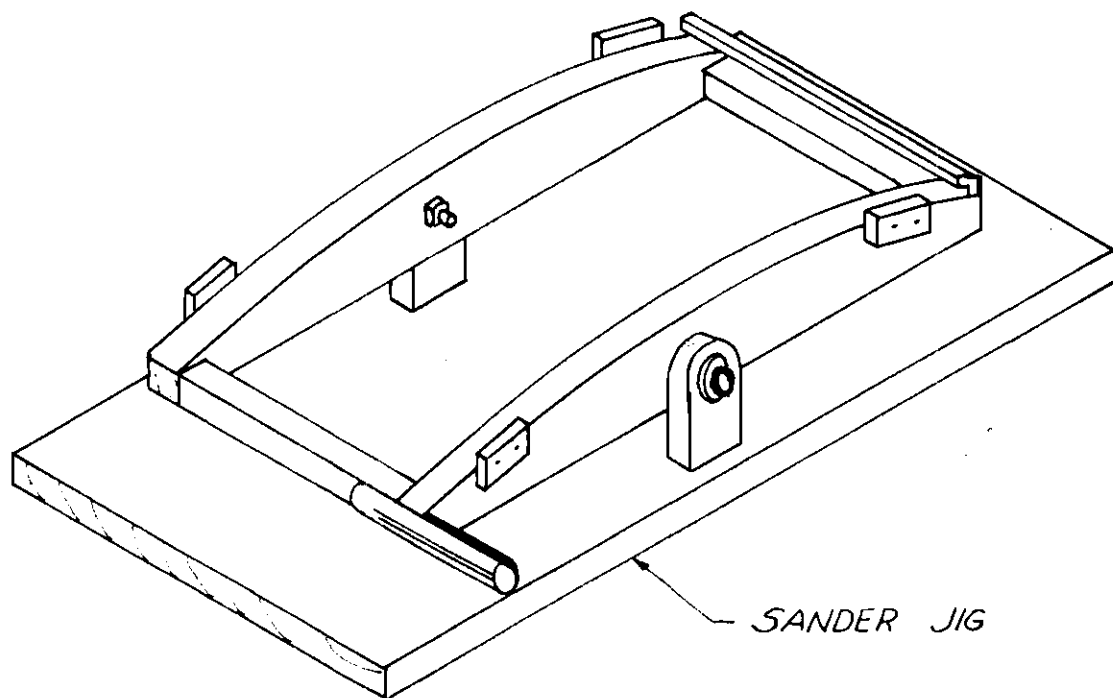


Fig. 59

Courtesy of The Mengel Co.

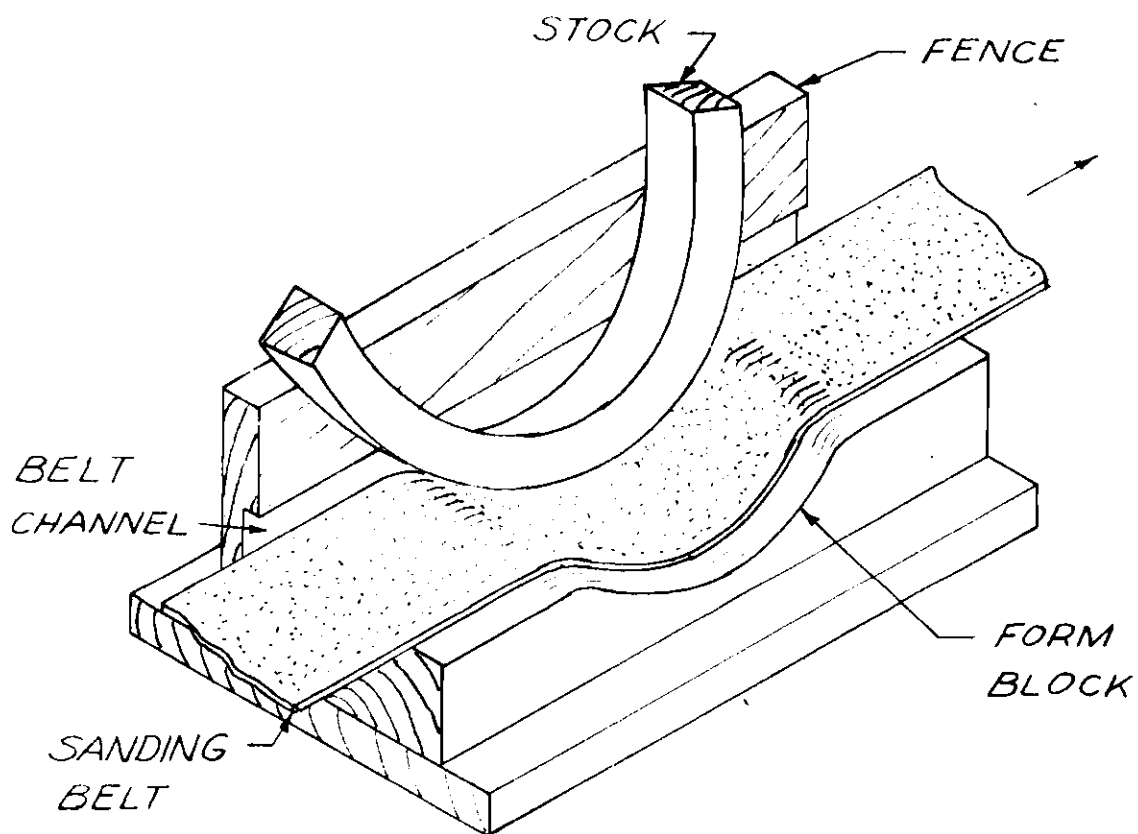


Fig. 60

Courtesy of The Mengel Co.

of the working edge while the work piece remains in one position. Also, the number of position changes is reduced due to the large contact area provided by the form block. The possibility exists, however, that the work can be pulled away from the operator, but the vertical fence serves as a substantial, positive brace.

Another design feature of this jig is seen in the belt channel which provides a recessed guide for the edge of the sander belt, thereby reducing the amount of concentrated attention required by the operator to obtain full width contact on the work. In turn, he is able to direct more attention to the position of the work and to the location of his hands relative to the sander belt.

Even for sanding such work as light chamfers on the corners of certain types of flat stock, a fixture similar to that shown in Figure 61 is beneficial. It consists of a box-like section mitered to the desired angle on one end. A cap fastened over this end forms an inclined rest that positions the stock for the chamfering operation. The sander table is locked to prevent transverse motion during the operation and the belt moves, abrasive side upward, under the fixture. By using this method of angular support, the stock is held firmly while the edge is formed accurately with little danger to the operator.

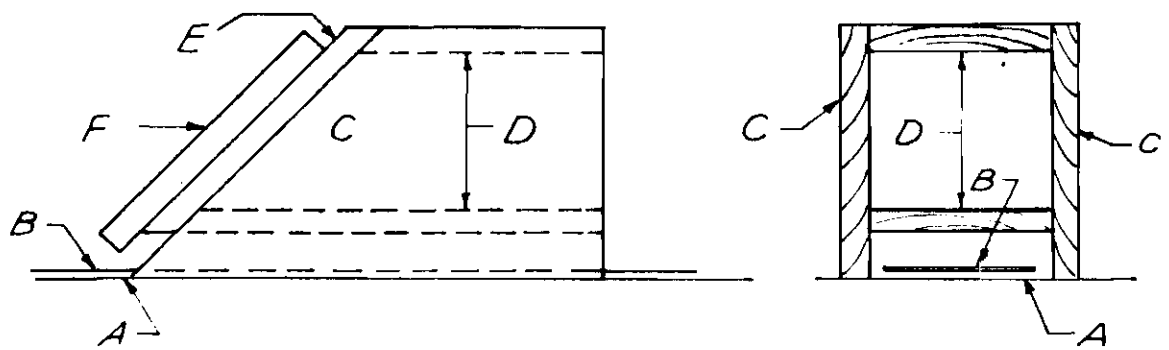


Fig. 61

- | | |
|---|---------------|
| A | SANDER TABLE |
| B | SANDER BELT |
| C | SIDE SUPPORTS |
| D | TOP & BOTTOM |
| E | CAP |
| F | WORK PIECE |

Courtesy of Williams Furniture Co.

STORAGE OF JIGS AND FIXTURES

The need for jigs and fixtures has been established; their usefulness has been observed and discussed. The question often asked in the woodworking industry is: "What can be done to prevent jigs from warpage, damage, or being completely lost in the large work rooms where they are used?"

Obviously, it is a problem of storage. If management takes no steps to solve it, the mill room becomes a maze of forms, layouts, templates, and fixtures. This practice, aside from presenting a disorderly appearance, causes a loss of much time on the part of personnel while looking through the various assorted piles to locate a certain item.

In leading furniture factories, the usual procedure is to assign a number to each piece manufactured. This number is further broken down through a system of serial numbers to indicate the various parts going to make up each item. Every jig or fixture built is then given the same number as that of its respective product.

With tooling properly coded, there still remains the problem of neat and orderly storage, so that any particular piece may be found with a minimum amount of time and effort spent on the part of the workmen.

In one plant⁸ visited by the writer, a room is provided for the storage of the accessories in question. Each form, pattern, fixture, etc., is systematically hung on a hook according to its number. One

⁸The Mengel Company, Louisville, Kentucky.

man is in full charge of this room, and maintains a card file record of each item's whereabouts. When an article is needed, it is checked out by the proper workman in a manner similar to that of modern tool room procedure.

This method encourages more extensive use of jigs and fixtures. If the worker must search the plant in order to find the necessary appliances, an inclination to do a job without the use of a jig is likely to result. This in turn brings forth more hazardous conditions and reduced production. Therefore, the problem of proper storage for jigs and fixtures deserves the same amount of concentrated attention that results in their development.

CONCLUSIONS

While it is acknowledged that the information in this study has of necessity been obtained from a limited number of plants in the furniture manufacturing industry, it is believed that those plants included are representative of that part of the industry which has given serious and extended consideration to the use of jigs and fixtures. The following conclusions appear to be justified as a result of this study:

1. Various machine operations in the furniture manufacturing industry have consistently experienced high rates of accident frequency and accident severity. It appears that the high speeds and sharp cutting edges required by the processing of wood are major factors in the excessive rates.
2. The proper safe machine operation depends upon the closely controlled relationship between the machine, the material, and the machine operator or other persons involved in the particular operation.
3. Many existing machine operations in the furniture manufacturing industry succeed in maintaining this relationship only through the use of fingers, hands, and other parts of the body in close proximity to the point of operation of the machine.
4. Numerous unbalanced forces by both the machine and the material are exerted in different directions and must be overcome to maintain the material in its desired position.
5. Jigs and fixtures of appropriate design may be used to restrict certain of the unbalanced forces, and thus reduce the requirements for such control as exerted by the operator.
6. In addition to the improved control of unbalanced forces and consequent tendencies toward motion of the material or machine, the use of well selected jigs and fixtures often permits the positioning of the hands at greatly increased distances from the point of operation.

7. While the use of well designed jigs and fixtures appears to materially reduce the hazards of machine operation, it will ordinarily be necessary to provide enclosures or other protection at the point of operation as well as in connection with other essential moving parts such as belts, pulleys, gears, etc.
8. The use of jigs and fixtures, in addition to safeguarding the operator from routine dangers, also provides additional protection to personnel not directly involved in the operation.
9. Effective jigs and fixtures are not ordinarily expensive to construct or install so that their use on small lot operations is not economically prohibitive.
10. Unless a jig or fixture is constructed substantially, so as to minimize chances of its failure, the hazards which it was intended to reduce may be increased.
11. While a few of the furniture manufacturing companies have used jigs and fixtures effectively, there appears to be a large percentage of the industry which has not yet put them to extensive use.

BIBLIOGRAPHY

BIBLIOGRAPHY

Colvin, F. H., and L. L. Haas, Jigs and Fixtures. Fifth edition; New York: McGraw-Hill Book Company, Incorporated, 1948. 410 pp.

Hjorth, Herman, Machine Woodworking. New York: Bruce Publishing Company, Incorporated, 1947. 336 pp.

Simonds, R. H., "Determining Accident Costs," National Safety News, 62: 22-23, August, 1950.

_____, "Band Sawing in Multiple," The Woodworker Magazine, 65: 40, December, 1946.

_____, "Spline Seating Cuts at the Shaper," The Woodworker Magazine, 67: 26, December, 1949.

_____, "Dowel Boring Furniture Parts," The Woodworker Magazine, 68: 69, May, 1950.

"Three Year Industrial Frequency and Severity Rates -- 1946-1948," Accident Facts. Chicago: National Safety Council Press, 1949.